METALLURGIC

CHYMISTRY,

IN TWO PARTS.

Metallurgic Chymiſtry.

BEING A SYSTEM OF

MINERALOGY in General,

AND OF ALL THE

ARTS ariſing from this SCIENCE.

To the great Improvement of MANUFACTURES,

And the moſt capital Branches of

TRADE AND COMMERCE.

THEORETICAL and PRACTICAL.

IN TWO PARTS.

TRANSLATED FROM THE ORIGINAL GERMAN

OF

C. E. GELLERT,

By I. S.

WITH PLATES.

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M DCC LXXVI.

TO THE

PRESIDENT

AND

MEMBERS

OF THE

ROYAL SOCIETY.

GENTLEMEN,

THE object of this Treatise, as one of the most extensive branches in Natural Philosophy, claims Your attention; and the utility arising from it, Your Patronage.

Commerce, which is one of the principal sinews of a State, cannot flourish

without

without a knowledge of the ſciences connected with it; and theſe cannot riſe to any degree of eminence, without ſtudying their theory; that is, without underſtanding the principles and foundation of each Art or Science.

Moſt of theſe Arts are ſtill practiſed without a phyſical knowledge either of their nature, ingredients, or effects; and as long as this is the caſe, they muſt ever remain defective, ſubject to error, and incapable of improvement.

In the peruſal of this Treatiſe, it will be found, what a number of uſeful and capital Arts are connected with, and depending on this branch of Natural Philoſophy, and in how maſterly a manner the Author has aſſigned the cauſes, as well as explained the effects, and principles of each Operation.

When

When an artiſt or manufacturer is aided with ſuch inſtruction, it cannot fail to lead him on to improvements of which he could have no idea before.

It is from ſuch motives of Public Utility that I hope this humble teſtimony of my endeavours will meet with Your approbation, which is the only and great ſatisfaction aimed at by,

GENTLEMEN,

Your moſt humble,

And moſt obedient ſervant,

JOHN SEIFERTH.

London, Aug. 20, 1766.

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OF

TO THE

READER.

THE merits of the preſent Treatiſe are ſuch as to need no recommendation of the Tranſlator: The Reader will find it the moſt concise aſſemblage of uſeful knowledge that ever has been preſented in ſo ſmall a compaſs by any author, diſcovering in a few ſheets all that was to be found uſeful and valuable, in this ſphere, amongſt the Works of great Authors, and ranging the various objects in that admirable chain of connexion as to make them ſerve a far more uſeful purpoſe than they did before. But nothing can equal the candour with which the Author imparts his own experiences, which are learned, ſolid, and true, and comprehend a great many very important diſcoveries and obſervations. His illuſtrations added to each Experiment

in the IInd. Part, are moſtly new, and true Specimens of a maſterly hand in theſe Subjects; and being all his own, they are Originals which have not yet been communicated to this Public. One undeniable merit of this work is, that it is the firſt by which this Science is brought into a regular Syſtem, ſo as to eſtabliſh an art, which had ever been left to a mere cuſtomary unprincipled practice, upon true, ſolid principels; diſcovering the reaſons and pointing out the cauſes of thoſe effects which before were not underſtood, amending miſtakes, correcting errors, and expoſing unfair practices, with equal Candour. Short as it is, it comprehends the foundation of many branches of the moſt important articles in practical knowledge, which cannot but be uſeful in many reſpects, chiefly to a Trading Nation, who by their own Learning and Underſtanding are ſo capable to make the greateſt improvements, often from a few hints. A great Manufacturer will find his account here more than he may expect from a ſtranger, perhaps from a friend, if he knows how to profit of it. How much, and to how various purpoſes are not artificial Compounds wanted, which indure the fire unalterably: Likewiſe ſuch, as on the other hand, are readily vitrifiable in a ſmall degree of heat; both which are the

Foundation of ſeveral very capital Articles in Trade. And what Art can be more intereſting than that of Smelting, chiefly of Ores and Metals in the great way; which is brought here upon ſuch clear, and true principles as no where elſe extant. Yet theſe are but a few inſtances, as it would be writing a much greater volume than that before us, to point out all the particular uſes of the things comprehended therein. Therefore none will think that I mean theſe common articles in the Practical Part of this Work, ſuch as to make Alcaline-Salts, Oil of Vitriol, Aquafortis, &c. theſe were only required in the courſe of the Syſtem, and are known to be found in other books. An intelligent Reader will better know to diſtinguiſh objects, and may perhaps not have obſerved all, after having read it over twice. For, beſides the almoſt numberleſs uſeful articles for many branches of Arts and Trade, there is likewiſe ſomething for the Philoſopher, the Connoiſſeur, and the Gentleman, which will deſerve attention and give delight. If he has not told you how to make crucibles, muggs, bricks, or glaſſes—do not blame him for that, for his buſineſs was not to write a receipt-book of that kind. You may ſtill learn all that, and much more from this, by a ſkilful application. For he teaches

you

you the Art and Principles, and leaves it to the intelligent Reader to apply them to proper Use.

Accept this small Present, which has long been withheld from the British Library, and do not look upon the faults of style and want of elegance, which are trifling and immaterial, and made up with an exact conformity to the original; but look with candour upon the public spirited Motives which have prompted me to act the part of

The TRANSLATOR.

London,
the 4th of June, 1776.

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THE

AUTHOR's PREFACE,

TO THE

Theoretical and Practical Part.

THE chief motive for writing this little Syſtem, was partly, becauſe it was required in the diſcharge of my office, partly becauſe there was really no Author extant, who had brought this Science into any tolerable ſyſtematical order. Before one can proceed with the examination of a Body, it is needful to underſtand firſt its Nature; and if a compoſed one, to know the parts of which it is compoſed. To this purpoſe I have, in the Iſt. Division of the *Theoretical Part*, endeavoured to teach the knowledge of Foſſil Bodies, and therefore begun to give, in the Firſt

First Chapter, an *Explanation* of this *Science* and of *Fossil Bodies* in general. In the Second, I have treated of *Earths*. In the Third of *Stones*. In the Fourth of *Salts*. In the Fifth of the *Phlogiston*. In the Sixth of *Metals*. In the Seventh of *Semi-metals*. In the Eighth of *Ores*, *Mineral-Earths* and *Waters*,

The parts of which Fossil Bodies are composed, cannot be *separated* without the addition or combination of some other body which may unite with those parts whose separation is intended, so as to be carried off with the combined body. If on the other hand, a fossil body shall be *united* with another body, the different component parts of both must enter each other with the most uniform Commixtion. This Commixtion is called *Solution*, and that body which has imbibed the other so uniformely as to constitute both a perfect mixture of equal proportion in all their parts, is called the *Dissolving-Agent*, or *Dissolvent-Menstruum*. But in general those bodies which either produce the intended change, or are assisting to it, are called *Agents* or *Instruments* It was therefore necessary to treat in the IInd. DIVISION, of the *Agents*, or *Dissolvent-Menstrua*, and particularly in the four first Chapters of the *four Operating-Instruments*, or *agents*, viz.

In

In the First Chapter of *Fire*. In the Second of *Air*. In the Third of *Water*. In the Fourth of *Earth*. In the Fifth of the *Dissolving-Menstrua*; and in the Sixth of the *Chymical-Apparatus*, as the *external Agents* or *Instruments*. In the III^d. DIVISION, I endeavour to give a just idea of *Chymical-Operations*. Here I have brought in all that is to be found in the best Chymical Authors, and whatever could be of service to the present purpose, yet without quoting always places and names, as being of no service but to swell the bulk of the book. It suffices to acquaint the Reader at once, that the Authors I have chiefly consulted in this Work, are Becher, Stahl, Henckel, Pot, Marggraff, Cramer, and others. But an intelligent Reader will find that I have not only brought these partly known things in a due order, but that I have introduced a great many new observations and illustrations of my own.

In the *Second*, the *Practical Part* of this Treatise, I have not only given all those Experiments as may come within the sphere of this Art, with the true and different methods how to proceed with each object; but I have added to each an Observation in which the Process is fundamentally explained, together

with

with the Uſes ariſing from it. As for the order into which theſe Proceſſes are brought, I have thought it neceſſary to begin with thoſe which teach the making of ſome of the diſſolvent-Menſtrua, as the chief Agents required in the Practice of this Art. Then I have proceeded with the preparing of theſe Menſtrua in the ſame order as they are treated of in the *theoretical Part*, ſhewing always what Bodies and in what Method they diſſolve one another.

The AUTHOR.

OF

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METALLURGIC CHYMISTRY.

PART THE FIRST.

Containing the THEORY of METALLURGIC CHYMISTRY.

DIVISION I.

Of the Nature and Objects of this Art.

CHAP. I.

Of the Nature of Metallurgic Chymistry.

§. 1.

METALLURGIC Chymiftry is an art which teaches how fubterranean or foffil bodies, by means of proper agents, may be changed, feparated or compounded, that fo we may difcover the feveral particular parts of their compofition, as alfo underftand their effects. Metallurgic Chymiftry, what

§ 2. In general thefe bodies are to be altered by the art of Chymiftry; and this change is faid tobe produced when compounded fubftances are divided

into

into their several constituent parts; or, if diverse elementary principles are some how united to form one compound body. Sometimes both these effects are produced in the same operation.

Its agent § 3. The alteration of a body cannot be effected but by the intervention of some other agent, such as will produce either the separation, or the union intended. Those bodies are called *chymical agents*, and shall be treated of in the second division.

§ 4. Since the greatest part of subterranean bodies are of such a nature, that their component parts may not be distinguished by the external senses, and as they cause different effects under different circumstances; it is by means of *chymical operations* that we endeavour to divide those bodies into their several parts, and to discover their effects.

Its objects § 5 The objects of Metallurgic Chymistry are all kinds of subterraneous bodies evident to the senses; whether they are naturally distinguishable, or are to be discovered by this art; either in reality or only so far that their existence may be judged of from their effects.

§ 6. All natural bodies are commonly divided into three kingdoms.

I. Subterranean Bodies, or Fossils.
II. Vegetables, and
III. Animals.

The present view has chiefly the fossil kingdom for its objects, and is no farther concerned with the other two than as they may be connected with this.

Fossils,

§ 7. *Fossils*, so called, are bodies generated as well in the bowels of the earth, as on its surface, and the parts entering their composition are so intimately blended together, that neither the strictest observation, nor the closest examination with the best microscopes, have hitherto been able to discover their combination; but every the minutest particle seems perfectly similar to the whole: notwithstanding it is apparent that in most parts of their bodies the fluid with the solid part must have been effected by some very particular admixture. **Fossils**

§ 8. All the known fossils may be comprehended under *eight* general *heads* or *classes*.

Eight Sorts

To the 1st,	belong	*earths.*
To the 2d,		*stones.*
To the 3d,		*salts.*
To the 4th,		*sulphur.*
To the 5th,		*metals.*
To the 6th,		*semi-metals.*
To the 7th,		*ores.*
To the 8th,		*mineral waters.*

CHAP. II.

OF EARTHS.

§ 9. EARTHS consist of very minute, almost impalpable particles, cohering very slightly; they do not burn, nor are they malleable, and are easily diffusible, but not soluble in water. **The First Class. Earth**

§ 10. Properly there are but two sorts of earth,

I. *Argillaceous earths*, which in the fire grow hard, and with the mineral acids are not dissolved.

II. *Alcaline*, or *calcareous earths*, which in the fire burn to lime, and dissolve in the mineral acids,

Argillaceous earths: Clays

§ 11. ARGILLACEOUS EARTHS consist either of spongeous, or of smooth tenaceous parts: the former is called, *vegetable earth* or *mould*; the latter, *clay*.

§ 12. Among the CLAYS are reckoned

I. *Potters earths*, viz,

1. Loam, which is coarse, irony, and very sandy.
2. Common potters clay, is heavy, without sand, of different substance and colour, whence some require a greater degree of fire to flux them, than others.
3. Fine clay, or china-clay, which is smooth and greasy to the touch, and of various colours.

II. *Medical earths*, such as

1. Boles and terræ sigillatæ, (sealed earths) and
2. Stone-marrow.

III. *Mechanical earths*, viz.

1. Tripoly.
2. Fuller's-earth, which lathers like soap and raises a froth in the water. But the true fuller's-earth must dissolve in acids, and consequently belongs properly to the marl-earths.

IV. *Painters*

IV. *Painter's earths*, which are

1. White.
2. Mineral yellow.
3. Umbre.
4. Mineral red.
5. Mineral blue.
6. Mineral green.

§ 13. To the ALCALINE OF CALCAREOUS EARTHS belong the following. Alcaline earths

I. *Chalk*, which is composed of fine dusty particles, adhering closely together and forming a pretty compact texture: it colours the hand upon being touched, and commonly it is white, but sometimes different in colour and kind.

II. *Marles* or *marl-earths*, are of a loose friable texture, easily reducible to powder, and most readily separating and diffusing in water.—When dug out of the ground, they are pretty hard, but being exposed to the air, they soon fall into dust. They are found of various colours, but seldom pure, being commonly mixed with some argillaceous earth. Some sorts of it are called *earth-marrow*, and barren soil may be manured with it to advantage.

CHAP. III.

OF STONES.

The 2d Class. Stones

§ 14. THE description of *stones* agrees exactly with that of earths, except that they are much harder, compact, and ponderous.

§ 15. A great many small, visible, but palpable stones, constitute what is called *sand*, which is named either *coarse* or *fine*, according to their size. Sometimes it consists of one species only, but often of two or more.

§ 16. All manner of *stones* may be comprehended under the four following *genera*.

Calcareous

I. *Calcareous* or *lime-stones*,

Which effervesce with, and even dissolve in the mineral acids; and in the fire burn to lime.

Argillaceous

II. *Argillaceous* or *clay-stones*

These are insoluble in acids, and burn to a hardness in the fire.

Gypseous

III. *Gypseous* or *plaster-stones*.

These are likewise not affected by acids, and in the fire burn to plaster, which being wetted with water, presently grows hard; differing therein from lime, which does not harden upon wetting, unless mixed with sand, and not then 'till after a long time.

Vitrescent

IV. *Vitrescent* or *glass-stones*,

Which suffer no change with acids, and in the fire run into glass. All this genus strikes fire with steel, except the glass-spar and the pumice-stone.

This

§ 17. This diviſion is grounded on the intrinſic nature and properties of ſtones: for, the difference ariſing from their value, flavour, uſe, hardneſs, form and colour, are all accidental: nevertheleſs theſe differences ſhall be taken notice of under their proper heads, as follows:

§ 18. I. CALCAREOUS or LIME-STONES. 1. Calcareous Stones

Theſe comprehend the following ſpecies.

1. *Lime-ſtones,*

Which are too ſoft for poliſhing; expoſed to the air they will crumble to pieces, though ſlowly, and in more or leſs time according to their quality: ſome are grey, others yellow, brown, red or green. When burnt in a ſtrong fire, it is called *quick-lime*; which when expoſed to the air, or moiſtened with water, grows warm, and falls in a fine powder called *ſlaked lime.* By chymical experiments it appears, that thoſe lime-ſtones contain not only a kind of the ſpirit of common ſalt, but at the ſame time a volatile alcaly. For, the fluid obtained from ſome of theſe by diſtillation, reddens the ſyrup of violets, and with mercury diſſolved in the nitrous acid, produces a ſublimate. The diſtilled liquid from other lime-ſtones turns the ſyrup of violets green. In the burning of lime-ſtones their ſmell proves that they contain a phlogiſton.

2. *Marble.*

This takes a fine poliſh, and in the fire as well as with acids produces the ſame effects as lime-ſtone. It is found of various colours, as white, grey, yellow, brown, red, black, green, and very often of a mixture of thoſe.

Common

1\. Calcareous stones

3\. *Common* or *lime spar,*
Is composed of oblong square plates or stratas. It is naturally heavy, and sometimes more so than any other stone. It is white, and of various degrees of transparency. In a gentle fire it cracks slowly, and becomes brittle enough to be rubbed to powder between the fingers. It is found of different figures, as in squared as well as hexagone shootings, &c. When plates are transparent, it is called *pellucid spar,* by the Germans *spiegel-spar.* Some sorts are more calcareous than others: the first kind does not dissolve in the mineral acids, the other does after being burnt.

4\. *Stalatites* or *drop-stone,*
Which consists of a calcareous earth, brought by water, and either in dropping down or in running forward left behind sticking in some hard body, where it collects and condenses: it is found of different colours, form, hardness, and weight, but is commonly light.

5\. *Marle-stone,*
Which is nothing but the earth called marl, condensed. If exposed to the air, it crumbles by degrees. Its colour is various, commonly whitish, but sometimes grey, or even blackish.

2\. Argil. stones

§ 19. II. Argillaceous Stones.

To those belong the following:

1\. *Shatites* or *soap-stone*:
Which is slippery in the hand like soap, is soft and easily to be scraped, cut, or turned; and in some degree to be polished. It comprehends the following species, viz.

a. Red

a. Red chalk, which is irony, and colours the fingers red when touched. Argillac. stones

b. Speck-stone (bacon-stone) which is somewhat transparent, hard, and variously coloured.

c. Smebr-stone or Spanish-chalk, which is opake, soft and whitish.

d. Tipf-stone, lapis ollaris, pot-stone, which is opake like the former, somewhat harder, and of various colours. Vessels made of it are hardened in the following manner, viz. by putting them in muffels of iron-plate, closed up with lute, and then burning them in a potter's furnace.

e. Serpentine-stone. Its colour is greenish, with black, yellow, and reddish spots and streaks. The largest vessels may be turned and cut of it; it polishes very well.

2. *Amianthus* or *rock-flax.*

Its texture is made of tender flexible fibres, lying both in parallel and transverse directions. It is light, swims upon the water, alters not in the fire, and is so pliable that it may be spun into thread, and made into cloth and paper, which is to be cleaned in the fire.

3. *Asbestus*

Is heavier than the amianthus; its fibres are more brittle, and run mostly in parallel lines. If the fibres are easily separated, it is called *ripe asbestus*, which may be spun and woven like the former, when properly prepared. But if the fibres are hard and do not separate without difficulty, it is called *unripe asbestus.* It is found of a grey, greenish, and of a blackish colour.

4. *Mountain-*

Argillac. stones

4. *Mountain Leather*
Hath flexible fibres disposed without any order, which gives it a loose foliated appearance. When the leaves are hard and thin, it has the name of *mountain-*(rock) *paper*; but when they are thicker and the stryæ harder, it is called *mountain-flesh*. If the stryæ are more interspersed, lay transverse, and loose, it looks like cork, and is called *mountain-cork*. This sort of fossil will melt in the fire to a black glass.

5. *Talc*.
This is composed of small shining scales or leaves, of an uneven surface, being greasy to the touch. It is called by different names according to its colour, as, *gold-talc*, *silver-talc*, *green-talc*, &c. &c. Its hardness is various.

6. *Mica* or *glimmer*.
Which is composed of small shining plates or scales of an equal surface and of a smooth touch: the following are the sorts of it, viz.

a. *Muscovy-glass*, which is transparent, and splits easily into very thin plates. It serves instead of glass for windows in many parts of Russia.

Nota. This must not be confounded with *selenite*, which is transparent and splits like this, but in the fire burns to a plaster. See § 20.

b. *Cat-gold*, *cat-silver*. So the glimmer is called by the Germans when it has the colour of gold or silver; and so likewise the other sorts of glimmer receive their denomination from their colours.

c. Black-

ε. Black-lead. It consists of small and thin scales, joined without order. Its colour is a greyish black, and leaves the same colour when touched. Argillac. stones

7. *Shirtus* or *slate.*
This consists of a condensed clay, is opake, not very hard, but harsh to the touch, and easy to be split into leaves or plates: the different sorts of it are as follow:
a. The *touch-stone,* which is black, pretty hard, and of a fine grain.
b. Black grind-stone, which is of a coarser grain.
c. Tile-slate; is the coarse dark-blewish, or grey sort.
d. Black chalk; this is very black, soft and foliated, and writes like common chalk.

Besides these, there are found other sorts of *shirtus* of several colours: Some run very easily into a black glass in the fire, which fusibility seems to arise from some admixture of irony particles. It is used at some places to fuse it into buttons, balls, and other things; and will serve to make a black glass for bottles, &c.

What the miners call kneiss, (rock) is mostly a grey and greenish shirtus, with a mixture of various other stoney particles.

§ 20. III. Gypseous Stones. Gypseous stones

Those include the following species:
1. *Plaster stone;* This is of a soft substance, but rough, mostly white or of a light grey colour; when broke it glitters, but does not take a polish.

2. *Alabaster;*

2. *Alabaster*; this differs from the former in that it takes a good polish, and is sometimes stained with variety of colours. There is white, black, streaked, and some of a mixed colour.

3. *Plaster-spar* or *selenite*; which is softer than the common spar, and mostly white. It consists of oblong squared transparent plates, lying one upon another. When it splits easily, it is called *maria glass*, in German *spiegel stein.*

4. Vitrescent stones

§ 21. IV. Vitrescent Stones.

Those comprehend the following species.

1. *Precious stones.*

Which are transparent, of several colours, and mostly of angular forms. And their specific characteristic is, that they resist the file. The various kinds of these are the following.

a. *The diamond*; is the hardest of all the precious stones, commonly without colour, yet some inclining to a yellow, blueish, or green hue, but very seldom red: If laid for some time in the sun, they become phosphoric and are luminous in any dark place, tho' indeed every chrystal and precious stone will do the same; also when made red hot in the fire, they emit light in the dark; and being rubbed upon glass 'till they grow warm, they give in the dark a silvery white shining appearance.

b. *The ruby*; Is of a deep red, and comes nearest to the diamond in hardness: When of a rose colour, it is called *Balass*, or a *pale ruby*: When of a light red, *spinel*; this last sort looses its colour in the fire, but not the others.

Saphire;

c. *Sapphire*; is of a sky-blue, and in hardness comes next to the ruby: It looses its colour in the fire. 4. Vitrescent stones

d. *Topaz*; is yellow, sometimes deep, but often pale; stands next to the sapphire in hardness, and keeps its colour in the fire.

Nota. A peculiar circumstance is to be observed with this fine sort of topazes, of which the author has not taken notice; which is, that they always grow in octangular shootings, by which they are distinguishable from the common topaz, which grows in hexagon shootings like other chrystals and fossils. This fine topaz is called in German *sbnecken stone*, and is always of a paler yellow than the other. And further it is to be observed, that by a certain method they may be deprived entirely of their colour, and acquire a lustre equal to the diamond, so as to be hardly distinguishable from that.

e. *Emerald*; is green; when made hot, it turns blue, and emits a light in the dark; when cold, its phosphoric light vanishes, and recovers its native colour.

f. *Chrysolite*; is of a greenish yellow, or orange colour, inclining to a green, which it loses in the fire. This does not resist the file.

g. *Amethyst*; is of a violet colour, sometimes inclining to yellow: It not only loses its colour in the fire, but even melts. It does not resist the file.

Garnet;

4. Vitrescent stones

h. *Garnet*; is of a deep red, but with different degrees of transparency. It melts in the fire, but keeps its colour.

i. *Hyacinth*; is of a reddish yellow, but sometimes only yellow colour. It melts in the fire, by which then it is distinguished from the topaz.

k. *Beryll* or *aquamarine*; is of a blueish pale green, or sea-water colour, and melts in the fire.

l. *Opal*; is of a milky, or rather mother of pearl colour, but shews various changeable colours, being turned in different directions.

2. *Mountain* or *rock-chrystals*, called *false stones*.

Those are found in hexagons, and do not resist the file. Commonly this species is without colour, but if coloured, it is named after that precious stone it most resembles. So if violet coloured, it is called a *false amethyst*: if yellow, *a false topaz*, &c. When the false topaz is very dark, it is called *smoak topaz*.

3. *Pebble*, *flint-stone*, or *kiesel-stone*; It has no certain figure, breaks in sharp, edged, semi-transparent pieces, and does not resist the file. The following are the species of it.

a. *Quarz.* This is what the miners name the hard transparent shining kiesel-stone (flint) It is called, like the mountain chrystal, after its colours, the *false precious stone*; for example, *false topaz*, *false amethyst*, *false emerald*, &c.

b. *Sand-stone*; consists of a multitude of small kiesel-stones combined together pretty firmly. It is, like the former, of various colours and firmness. The coarse sort serves

for

for *mill-stones*; the finer, for *grind-stones*. When it is of so loose a texture as to let water through, it is called *filtering-stone*. 4. Vitrescent stones

4. *Corneous* or *horn-stone*; it breaks either into concave or convex pieces; has no certain form and resists not the file. Its species are the following:
   a. *Calcedony*; which is of a blueish milk colour, nearly simipellucid, and bears polishing well; in the fire it turns white. It comprehends two sorts, viz.
      1. *Onix*; so the chalcedony is called if marked with black streaks.
      2. *Sardonix*; when it has black and red streaks.
   b. *Cornelian*; is red, semitransparent and polishes well.
   c. *Agate*; is semitransparent, of a mixed colour, and takes a fine polish. It has many names given from its colours, and variety of figures represented therewith.
   d. *Jasper*; is opake, of many single or mixed colours, of different degrees of hardness, and therefore some will not polish.
   e. *Common horn* or *flint-stone*, called by the Germans *fire-stone*; has some degree of transparency, and is of a coarser texture than the former sorts.
5. *Glass-spar*, called by the Germans *fluss-spar*, is a soft foliated stone of various forms and colours. It breaks into oblong squared semitransparent pieces, and is often very like the calcareous spar in its foliated texture and cubic form; but it is distinguished from it by means

4. Vitreſcent ſtones

means of aquafortis; and its difference from the plaſter-ſpar is as readily found out by burning it in the fire. When this *glaſs-ſpar* is *coloured*, it is called, like the chryſtals, *falſe ſtone*: ſuch as *falſe amethiſt*, &c. It makes a very good ingredient for fluxing refractory ores, (whence it has the name *flux-ſpar.*) Such as are of a very bright and deep colour, as the green and blue, when made pretty hot or being gently burnt, appear phoſphoric in the dark, like the *bononian-ſtone*, which itſelf is nothing elſe but a kind of glaſs-ſpar.

6. *Pumice-ſtone*; is rough and porous, ſo light as to ſwim upon the water, and of a ſtriated texture, or rather of a wood-like grain. It is ſaid to be found frequentiy about the volcanos and hot baths, and thence ſuppoſed to be a ſort of ſea-coal burnt out by ſome ſubterranean fire.

§ 22. Frequently two or more of the above enumerated ſorts of ſtones are mixed together into one compound; and in that ſtate moſt ſorts of hornſtones are found in the cornelian mine, as it is called, near Freyberg in Saxony. The *common rock*, is a mixture of flint-ſtones, ſpar, glimmer, ſlate, and often of more ſorts.

§ 23. Moreover ſeveral diſtinctions take place among ſtones with reſpect to their accidental qualities, without regarding their intrinſic properties.

So we call that an *eagle ſtone* which contains in its central cavity another compact body, which is looſe and rattles when ſhook; tho' it is nothing more than a marl or a flint-ſtone. So likewiſe a

ſpecies

ſpecies of conoide ſtones is called *belamnite*, or thunder-bolt. And when a ſtone has the form of an animal or of a vegetable, it is called a petrefaction, and of that body which it reſembles, as a *petrified crab*, *ſhell*, *wood*, *&c.*

CHAP. IV.

OF SALTS.

§ 24. SALT, is a body ſoluble in water, and either melting in the fire, or becoming volatile; and is not inflammable. Salts

§ 25. In general the pure ſimple ſalts, are of two ſorts only, viz.

I. The ACID, and

II. The ALCALINE.

§ 26. When theſe two ſorts unite with another body, or with themſelves alone, a *ſal intermedium* or *neutral ſalt*, is produced.

§ 27. The characters of a *pure* ACID *ſalt*, are theſe Acids

1. With alcaline earths, (§ 13) and ſtones (§18) likewiſe with egg-ſhells, crabs-ſtones, ſea-ſhells corals, it produces a boiling ebulition, called *effervescing*, by this means the alcaline body will be diſſolved, either wholly or in part.
2. When diluted with water, and poured into moſt of the blue juices expreſſed from vegetables, it turns them red.

Salts

3. It is diſſipated in the fire, or is altered, if not united with ſome fixed body.
4. It is to be known by its ſmell or taſte.

§ 28. *The* ALCALINE *ſalt* diſtinguiſhes itſelf by the following effects.

1. It effervesces with the acids in the like manner as theſe do with the alcaline earths and ſtones.
2. It changes moſt of the blue juices of § preceeding, into green.

§ 29. *Neutral ſalt* or *ſal medium*, (§ 26) produces neither the effect of the acid (§ 27) nor of the alcaly (§ 28.)

Acids

§ 30. The *acid* of *vitriol* or *acid* of *ſulphur*, (+⊕) is the ſtrongeſt of all acids; for, if preſented to ſuch a body with which any other acid is combined, it expells that acid, and aſſumes its place by uniting with the ſubſtance itſelf. When concentrated, it

Of Vitrol

is called *oil* of *vitriol*, (∘∘∘⊕). This is much heavier and more fixed in the fire, than any other acid. Its natural weight is ſeveral times heavier than water: neither the warmth of our clime, nor even that of boiling water, is able to produce any ſmell from it.

Of Nitre

§ 31. *Acid* of *nitre*, or *ſpirit* of *nitre*, (+⦶). Is of a pungent diſagreeable ſmell: it is weaker than the vitriolic acid, but ſtronger than the acid of common ſalt. If concentrated, it is of a yellow colour and emits a fuming vapour, which, if very denſe, looks red, but when rarer, it is of a greyiſh colour.

Acid

§ 32. *Acid of common salt*, the *marine acid*: Is easily distinguished from the nitrous acid by its smell, which, tho' disagreeable, is very different from the former: as also by its particular effects, which shall be explained in the practical part. When concentrated, its colour is a greenish yellow. Salts Marine

§ 33. *Vinegar* (+) or the *acid* of *vegetables*. Altho' the acid of that kingdom does not belong properly to this place; yet its use being so general in chymistry, it could not be left unmentioned. It is found in the common vinegar, wood, tartar, and in all sorts of sour fruits. Vinegar

§ 34. The *fixed alcaline salt* is to be obtained, both from the *fossil* and *vegetable kingdom*. Alcaline fixed

In the *fossil* or *mineral* kingdom, it is discoverable;

- *a.* In *medical springs*, but chiefly in those whose smell is like rotten eggs; as in these of Carlsbad, Aix la Chapelle, Spa, Sedlitz, &c. This salt is sometimes found adhering to the earth where the water has evaporated. From Fossils
- *b.* In the *common salt.*
- *c.* Partly in *nitre*: for, this itself contains a part of the vegetable alcaly.

From the *vegetable kingdom* it is obtained by incineration, elixivation and evaporation, viz. From Vegetables

- *a.* From the *Spanish soda*, which is made from plants growing on the sea shore, and thence it contains at the same time some portion of the common sea salt. With this soda, finer and more durable glasses are made, than with the salt of common ashes; for, the glass made with common potashes, is sooner

Salts.

affected by acids, than these, and will even sometimes crumble in the air.

b. Potashes, are made from all sorts of vegetables. When any plants are burnt, and their ashes elixivated for medicinal purposes, the fix'd alcaline salt obtained, is called after the name of the vegetable it was produced from: as, *Sal Absinth, C. B. Genistæ.*

c. Salt of *tartar*, (⊖♃) *ri*, is made from calcined tartar; and exceeds both the soda and pot-ashes, in purity, fusibility, and pleasantness of taste.

§ 35. The *fossil fixt alcaline salt*, distinguishes itself from the alcaline earths, by dissolving in water: for earth is insoluble. (§ 9) It agrees in most particulars with the fixed alcaline salt of vegetables; but differs from it, as follows, viz,

1. It does not liquify in the air; whereas the fixed alcaly of vegetables, being exposed to the air, attracts the moisture of the atmosphere and dissolves into a lye, which is four times heavier than the dry salt was before, and then it is called *oleum tartari per deliquium*, or lixivium of tartar.
2. That of vegetables is also much sharper than that of fossil bodies.
3. When the fixed alcaly of vegetables is united with the vitriolic acid, it produces a neutre salt, which does not flow but by means of a strong fire, and is very difficult to dissolve in water. But the acid of vitriol, united with the fossil alcaly, produces a neutral salt which easily dissolves in water, and soon runs in the fire

fire. The first is called *vitriolated tartar*, the other when made of common salt, Glauber's *sal mirabile*, or simply *Glauber's salt*. Salts.

§ 36. *Sal fixum nitri*, and *sal tartari extemporaneum*, called the *black flux*, are no particular sorts of fixed alcalies. For the first is only nitre (⏀) with the addition of coal-dust; the other is made of nitre and tartar.

§ 37. Under the name of *volatile salt*, is commonly meant the *volatile alcaline salt*. Yet as there are also volatile salts of *acids*, the word *alcaline*, must be added. It is very rarely found in the fossil kingdom; tho' it is sometimes to be discovered about medicinal springs, as is, at Lauchstædt near Merseburg in Saxony, in some of those earths and stones. But it may be obtained in great plenty from the vegetable kingdom, as, from wood, soot, and from all putrefied vegetables: but the greatest quantity is to be found among the animal tribes. From the dry animal substances, such as horn, hair, or bones, it may be produced by the assistance of fire alone: but to obtain it from the soft and fluid parts of animals, the easiest way is by means of putrefaction. This salt is to be had in a dry as well as in a fluid form; if liquid, it is called an *Alcaline Spirit* (—♌—□); if dry, it is particularlized by the name of the *volatile alcaline salt*. By the word, *urinous*, a volatile alcaly is commonly understood, because the spirit and volatile salt of urine are the most frequent. Volatile alcali. Urinous.

Among the volatile alcaline salts the best known and most in use are, the *spirit* and *volatile salt of urine*, of *hartshorn*, of *soot*, of *vipers*, and the *spirit*

Salts of *sal armoniac*, as well simple, as made with quick-lime.

Common Salt § 38. When the *acid* of *sea-(common) salt* is united with a fossil alcaly, it produces a neutral salt, called *common salt* (⊖) And this salt is to be obtained,

a. Partly in a solid form dug out of the earth, as at Cracovie in Poland, and is called *rock salt*, or *sal gem*.

b. Partly from the sea-water, and some lakes.

c. Partly from springs, on the continent as well as in islands.

The figure of its chrystals is cubical. In the fire it flies to pieces with a crackling noise which is called its decrepitation. It dissolves in four times its own weight of water, either cold or warm.

Bitter Salt § 39. The *fossil alcaly* combined with the *vitriolic acid*, produces a medicinal spring-water salt, such as that of Epsom in England, and of Eger in Bohemia. Its figure is a square column. This is called the *bitter purging salt*.

Salt-petre § 40. The *nitrous acid* joined with an *alcaly* partly *vegetable* partly *fossil*, produces salt-petre, nitre (⦶). The figure of its crystals is an hexagonal prism, terminated by pyramidical columns, having the same number of angles, and the opposite sides commonly of the same breadth. It is white and nearly transparent. If in the fire it comes into contact with any substance containing a phlogiston, it deflagrates with much noise, burns with a very white bright flame, quickly consumes the phlogiston

phlogiston, and leaves a great portion of a fixed alcaly behind. A greater quantity of it will dissolve in hot water than in the cold. Its taste is sharp and saltish, which leaves upon the tongue a sensation of coldness. Salts.

§ 41. When an argyllaceous earth is combined with the vitriolic or sulphureous acid, another neutral salt arises, called, *alum*, (O) which is white, sometimes inclining to a very pale reddish hue. Its chrystals are of an octohedral figure, and its taste is sweetish, nauseous, and styptic. It dissolves better in hot water than in cold. It differs in quality according to the nature of the earths, stones, or other ingredients it was made with. Allum

§ 42. If a metal be dissolved in an acid, either by nature or art, and then evaporated so far as to shoot into chrystals, the salt obtained is called a *vitriol*, or sometimes *sugar*, likewise *salt*, with adding the name of the metal it was made from.— As, *silver-vitriol*, or *salt* of *silver*, *copper-vitriol*, *sugar* of *lead*, &c. There are only three sorts of native vitriol known, that is, such as are found composed by nature, viz. Vitriols.

a. The *blue vitriol*, of copper.

b. The *green vitriol*, of iron.

c. The *white vitriol*, of zinc, called likewise, by the Germans, gallitzen stone.

§ 43. *Tartar* is a neutral salt, consisting of the vegetable acid, an inflammable earth, and an ardent spirit. Tartar

Sugar

Salts Sugar

§ 44. *Sugar* consists of an acid from the vegetable kingdom, and an inflammable spirit or oil, united with an alcaline earth.

Borax

§ 45. *Borax* is a salt brought native from the Eastern countries, mostly from Egypt, and is chiefly refined in Venice, but some in Holland. It is not yet certain whether it is natural or artificial: there is, however, pretty good advice of its being the product of art. In a warm air it becomes powdery on the surface. It dissolves with difficulty in the water; in the fire it quickly swells up and runs into a soft glass which attracts the air.

Salt armoniac

§ 46. *Salt armoniac* (⊖✱) consists of the marine acid combined with a volatile alcaly. In Asia, and at Puzzolo in Italy, it is found native. It is said that in Venice and Egypt they make it of common salt, urine, and soot. Its taste is like that of common salt, but sharper. It dissolves easily in water, and in the fire becomes volatile and flies off.

Neutral Salts

§ 47. Besides these, there are many other artificial combinations of acids and alcalies, and consequently various sorts of neutral salts produced: for example;

1. *Arcanum duplicatum*, which consists of a vegetable fixed alcali or nitre, combined with the vitriolic acid, If the vegetable alcaly is a salt of tartar or of pot-ashes, it is particularised by the name of *vitriolated tartar*.
2. *Sal mirabile*, or *Glauber*'s *salt*, is composed of the vitriolic acid, combined with the alcaline basis of sea-salt.

3. *Sal*

3. *Sal digestivum Sylvii*, which is a combination of the acid of marine salt with a vegetable alcaly. Neutral Salts

4. *Sal sulphuratum*, called *sal polychresticum*, consists of the vitriolic acid with the alcaline part of nitre.

5. *Sal seignette*, named from the inventor, Seinette's salt; is made of soda and the acid of tartar.

6. *Sedative Salt*, is a mixture of the acid of vitriol with the vitrifying part of borax; and is obtained by subliming the borax when moistened with oil of vitriol diluted with water, or mixing the borax with calcined vitriol.

7. *Arcanum tartari*, called also *terra foliata tartari*, and regenerated tartar; consists of distilled vinegar saturated with salt of tartar.

8. *Tartarus tartarisatus*, tartarised tartar, is the acid of tartar (in chrystals) combined with the alcaline salt of tartar.

9. *Tartarus solubilis*, consists of tartar and a volatile alcali.

10. *Nitrous sal armoniac*, consists of the acid of salt-petre and a volatile alcaly.

11. *Glauber*'s *secret salt armoniac* is the vitriolic acid combined with a volatile alcali.

12. *Acetous salt armoniac* is made of distilled vinegar and a volatile alcaly.

13. *Salt armoniac*, which comes nearest to the common sort, is a combination of the marine acid with the volatile alcaly.

CHAP.

CHAP. V.

OF SULPHUR OR THE PHLOGISTON.

Sulphur

§ 48. EVERY substance what is inflammable, is in Chymistry called by the general name of *sulphur*, or *phlogiston*. It is found in all the three kingdoms of nature, even in the air; but seldom or never alone, being always united with some other bodies.

§ 49. In the mineral or fossil kingdom it appears

Petroleum

1. In a liquid form, and is called *petroleum*, *rock-oil*. The white sort which is very volatile and attracts the flame, is called *mountain-balsam*, and *naphta*. The yellow and brown sorts are called *rock* or *mountain-oil*; and when it is black and thick, *rock* or *mountain-tar*. It is found either spontaneously flowing out of rocks, or swimming upon water.

2. In compact bodies, such as

Ambergrise

a. *Ambergrise*, which is a tenaceous pretty hard substance, which when burnt sends forth an agreeable odour.

Amber

b. *Amber*, (Bernstein) This is found either white, yellow, brown, or of a red colour: It admits of cutting, turning, and polishing; and gives a fragrant smell in burning.

c. Earth-

c. *Earth-pitch*, which is of a black or dark-brown colour, and when burnt, gives a nauseous smell: Its species are, *mountain-wax*, *jews pitch*, *sea coal*, *bituminous earths*, *turf*, and *jet*, which latter admits polishing. Sulphurs Earth-Pitch

d. *Sulphur* (🜍) which consists of the vitriolic acid, combined with the purest inflammable matter or phlogiston. In burning, the fume arising from it, is noxious and suffocating. It is to be had either *native*, or *artificial* from ores and earths. Its principal ore is the *pyrites*, (kiess) tho' it is found in almost every kind of mineral. When of a transparent red, it is a sure sign of being mixed with arsenic. The pure, yellow, transparent, native sulphur is called, *virgin-sulphur*. The red, *sandarach*, (raush-gelb) The orange coloured *ruby-sulphur* and *arsenical ruby*. Brimstone Sandarach

§ 50. In *the vegetable kingdom*, the *inflammable matter*, or *phlogiston*, exists in great abundance, but chiefly

a. In *resins*; as myrrh, mastic, &c. and are soluble in spirit of wine; wherein they differ from gums, which will dissolve only in water. Resins

b. In *oils*; which are either *distilled*, or *expressed*. The first includes *oil* of *turpententine*, *oil* of *roses*, &c. Among the latter, *oil* of *almonds*, of *nutmegs*, *walnut*, *linseed-oil*, &c. Oils

c. In

Balſams *c.* In the *balſams*; which are thicker than oils; as in the *turpentines*, *balſam* of *Mecca*, or *Peru*, &c.

§ 51. The phoſphorus; made of animal parts, proves the exiſtence of a phlogiſton in the animal kingdom.

CHAP. VI.

OF METALS.

Metals § 52. METALS ſo called, are compact bodies, perfectly opake, more ponderous than other foſſil ſubſtances, fuſible in certain degrees of fire, and capable of being extended every way by the hammer.

Theſe are only ſix in number, viz.

Gold, *Silver*, *Copper*, *Lead*, *Tin*, *Iron.*

Gold § 53. *Gold*, (☉) is the pureſt, heavieſt, and moſt fixed of all metals. It looſes between 1-19th and 1-20th of its weight in pure water. It melts in the fire ſo ſoon as white hot, and then its colour looks of a ſea-green. It is very pliable and tough; but when by repeated bendings it is broken, the ends have a ſmall priſmatical edge; whence it is almoſt without any ſound. Its colour is a bright yellow. It reſiſts the ſtrongeſt aquafortis.

54. The

§ 54. The specific weight of a body, which does not dissolve in water, may be examined with any sort of good scales, in the following manner. Metals

Fasten the body with a horse-hair at the end of one arm of the beam, and note its weight in the air; then immerge the body with the horse-hair in water, (which is to be in readiness to that purpose) and put so many weights in the same scale as to restore the equilibrium: Lastly, divide the weight which the body had in the air, by the difference it has in the water, and the quotient will be the specific weight of the metal. But it is to be remembered that these examinations are liable to some uncertainties, from the following reasons; viz.

1. The difference of the gravity of the water.
2. The various degrees of warmth in the atmosphere; which alters the bulk of liquids much more than that of solids, chiefly of metals.
3. The metals themselves being seldom perfectly pure, but usually intermixed with some other metals of different gravity.

Nevertheless these impediments do not altogether prevent metals from being discovered and distinguished by their specific gravity in the hydrostatik balance; unless they are very impure.

§ 55. *Silver*, (☽) is of a white very bright colour. It looses about 1-11th of its weight in water. It is as fixed in the fire as gold, but melts with rather a less degree of heat. Next to gold it is the most distendable under the hammer; and is not soluble in the best aquaregis (♈R). Silver

26. *Copper*,

Metals Copper

§ 56. *Copper*, (♀) is of a reddish colour, hard, and sonorous. In water it loses 1-8th to 1-9th of its weight. It is very tough and malleable, but not quite in that degree as the two foregoing. Upon breaking, it appears granulous, and rather dull than shining. It requires a greater heat to melt than the silver; and when in fusion, it gives a blueish green colour to the flame of the fire. It is somewhat fixed, but may be destroyed in the fire by degrees: for, the phlogiston being driven out, leaves the remainder in the form of a metalline calx. It is affected and corroded by every kind of salt and acid, and even of that in the air, and then assumes several colours, especially blue and green. Among all the metals only this is changed into a yellow metal by zinc, or any substance containing zinc; and then it is called *brass*, or yellow *prince-metal*, if made with pure zinc; which two metals differ in colour and malleability; the latter being a deeper yellow, and more brittle than the former.

Lead

§ 57. *Lead*, (♄) is of a whiteish blue, looses in water between 1-11th to 1-12th of its weight: it is the toughest of all metals, and therefore if broken shews a smooth prismatic surface or edge; in the fire it melts before it grows red hot, and then is soon destroyed, a considerable portion exhaling, while the remainder according to the degree of fire, either calcines into a powder, or runs into a glassy substance called *lytharge*, which is either yellow, red, or black. Being the softest of all metals, it gives little or no sound.

Tin

§ 58. *Tin*; (♃) is of a white shining colour, almost like silver: it looses 1-7th of its weight in the water, which proves it to be the lightest of all metals: it is rather less malleable than lead, yet by no

no means brittle, being the next in softness to lead. Metals
Upon bending it between the teeth, it makes a sort of crackling noise, by which it is distinguishable from all other metals; it flows like the lead in a very little heat, long before it is red hot, when it easily parts with its phlogiston and falls into a whitish calx, which proves the whiter as the heat has been given more or less.

§ 59. *Iron*; (♂) is of a water colour, and Iron
looses in water from between 1-7th to 1-8th of its weight. It is of a very great fixity, and does not melt but with the most violent degree of heat, and then loses much of its substance. When made very hot, or being in fusion, it throws out bright sparks, and partly goes off in fumes, while another part runs into a dark brown blueish glass, and the rest becomes scoria; it is the most brittle amongst metals, and this brittleness increases when made red hot and then suddenly quenched in water. It is the only body in nature which attracts and is attracted by the magnet.

§ 60. These four last described metals, are called *imperfect metals*, because they are not indestructible in the fire like gold and silver.

§ 61. *Mercury*, (☿) is commonly reckoned a- Mercury
mongst the metals, tho' it is neither malleable nor solid. The only particulars in which it agrees with metals, are its great ponderosity, and perfect opacity. In water it looses 1-14th of its weight; when pure it preserves its fluidity in the greatest degree of cold; but in a moderate heat it evaporates entirely in fumes, which being collected, the same mercury is obtained again. It may be changed va-

rious

rious ways, and yet may almost always be restored to its first form and nature.

CHAP. VII.

OF SEMI-METALS.

Semi-metals § 62. SEMI-METALS, differ from metals principaly in their want of malleability, but they are also much less fixed in the fire, where they become entirely volatile.

There are five sorts, viz.

Zinc, *Bismuth*, *Regulus of antimony*, *Arsenic*, and *Cobalt*.

Zinc § 63. *Zinc*, (X) Is of a white blueish colour, and brittle in comparison of metals, but tougher than all the other semi-metals, admitting in some degree of the hammer: When broken it looks as if its whole texture was a compound of loose cubical grains. It melts in a very moderate heat, so soon as it begins to be red hot; and by increasing the fire, it soon raises in fumes, which sticking to any solid body, remain in the form of a white light wool, which is called *flowers of zinc*. If the fire is further increased, it inflames and burns with a fine green colour, 'till all is consumed and gone off.

Bismuth § 64. *Bismuth*; (W) This being broken, appears of a cubical texture, whose cubes consist of thin plates or lamina: it differs but little in appearance from the former, yet its colour seems to be

be more of a yellowish cast than blueish; it is very brittle, and melts before it is red hot. Semi-metals

§ 65. *Regulus of antimony*; is of a pretty whitish colour, but very brittle and hard; it requires a stronger fire to bring it in fusion than the former, and will not melt 'till it is grown pretty hot. Regul. of antimony

§ 66. *Arsenic* (o-o) takes place among the semi-metals from its likeness to their metalline form: for, tho' it is found partly in a white powder of a shi[illegible]g white colour, and semi-transparent, yet a li[illegible]logiston reduces it to its semi-metalline f[illegible]pates in the fire, but with a much th[illegible]ur than the former, the colour of it is a [illegible]rey, emitting a strong smell of garlick: It [illegible]er than all metals and semi-metals, and [illegible] most volatile and unfixed, (tho' its or[illegible]commonly the heaviest of all.) The white ar[illegible]ic in its powdery form may with some propriety be placed among the salts, because it will dissolve in thirty times its weight of boiling water. It is the most offensive poison, (after the fumes of mercury,) and therefore its smell is to be avoided with the greatest precaution, the least sensation of a sweetish taste being observed upon the tongue, one must carefully spit out the saliva, as with that the poison would be swallowed down. Arsenic

§ 67. *Cobalt*; (K) is grey, yet something inclining to a yellowish cast, very like the bismuth, but of a foliated texture: this is the semi-metal, which when sufficiently roasted, communicates a blue colour to glass; whence it has been looked upon rather as a metallic earth, but with no suffi- Cobalt

Semi-metals cient reason: for, even metals themselves, when reduced by fire, or any other method into the form of an earth or calx, give several colours to glass. And that *cobalt* is a real semi-metal, will appear from thence,

1. Because it has the ponderosity of a metal.
2. Has also the external appearance and form of a metal, and
3. It melts in the fire like a metal, tho' not without a pretty strong heat; and when cold, shews a convex surface.

In aquafortis the *cobalt* dissolves with great violence and with abundance of poisonous fumes: and if the cobalt is pure, the solution must be of a yellowish green colour, which upon adding a fixed alcaly, turns black; but if a volatile alcaly is added it falls down into a high red precipitate, which being edulcorated and brought to fuse with any inflammable matter, (phlogiston) recovers its metalline form again. Cobalt does not amalgamate with mercury, nor does it unite in fusion with arsenic, with bismuth or with lead: therefore in smelting-houses, where cobalt ores are worked with lead, it is found swimming upon the surface of the melted metal, whence the workmen separate it, and being ignorant of its substance, often work it for silver, of which however it holds very little or none at all; whereas it would serve to a much better purpose; for, one centner or pound of it, being roasted, will make thirty or forty pounds or centner of the finest blue glass; when the roasted cobalt-ores, colour only from eight to fifteen.

CHAP.

CHAP. VIII.

OF ORES.

§ 68. THOSE mineral bodies which consist of metals or semi-metals, and of sulphur and arsenic, or of both together, are called *ores*. Sometimes they are likewise mixed with unmetallic earths or stones. Ores

§ 69. In collecting or purchasing of ores, care must be taken to prevent imposition: for, there are some ingenious fellows who know how both to compose artificial ores, and to join natural pieces so artfully together, that the cheat may not easily be discovered with the eye; from whence many theoretical and practical errors may arise. Oftentimes this cheat may be detected by putting such mineral stones into hot water, or in brandy, for, if they are joined with gum, or resinous substances, one or the other will make them fall in pieces. (See § 20.)

§ 70. *Ores* are divided, with respect to their effects in the fire, into three sorts.

1. *Fusible*, which either by themselves, or with the help of a proper menstruum, become perfectly fluid in the fire.
2. *Stubborn* or *difficult*, which require a violent heat and long continued fire to flux.

Ores

3. *Refractory*, which do not flux alone in the ſtrongeſt fire, but require the greateſt aſſiſtance from other additional menſtrua, and even then are with difficulty brought to perfect fuſion.

However it may eaſily be imagined that in each of theſe claſſes, various degrees will occur.

§ 71. Mineral-bodies muſt neceſſarily produce as many different effects in the fire, as they are variouſly intermixed with different ſubſtances.

As therefore ores are themſelves compounds, (§ 68) and caſually joined with other foreign matters; their different effects in the fire muſt depend as well upon the heterogeneous mixture, as of the ſubſtance of the ore itſelf.

§ 72. Some of theſe mixtures being lighter than the ore itſelf, may be ſeparated by pounding and waſhing, but often it will be needful to roaſt them firſt. Thoſe are called *ſeparable ores*; but when the nature of the heterogeneous matters are ſuch that they will not admit of this ſeparation, either by fire or water, or if they are too much entangled with the very ſmall particles of the ore, then they are called inſeparable ores.

§ 73. A *rapacious-ore* (called by the workmen a *wolff*) is ſuch, when intermixed or involved with ſome deſtructive matter, which in the fire deſtroys more or leſs the metalline particles of the ore, either by carrying it away in fumes, or by converting it into an irreducible ſcoria.

OF GOLD.

OF GOLD.

§ 74. It is not certain if there be any ſuch thing as a real gold ore; that is to ſay, where the gold is intermixed and penetrated with ſulphur or arſenic: becauſe naturally gold is found in its perfect metallic ſtate, though ſometimes ſurrounded caſually with other ores. Gold

§ 75. This *native gold* is moſtly found in flint, or white quarz; though ſometimes in other ſorts of ſtones, ſuch as horn-ſtone, lapis lazuli, (as commonly believed) and now and then in the midſt of a mere ore, ſuch as marcaſites, (pyrite) and often in iron-ore.

§ 76. There is hardly any kind of ſand without gold, only that they differ in the quantity. Sand in or near rivers, eſpecially where the ſtream makes any turning, is commonly richer than the other. It is likewiſe found in moſt of the fat loamy earths, out of which it is to be obtained by waſhing, and thence called *waſh-gold*. And here a peculiar circumſtance ariſes with regard to the near relation of iron with gold. For after the ſand and earth is waſhed from this gold, ſome ſmall brown or black iron grains are uſually found among it, which are called *iron-ram*, and are attracted by the magnet.

§ 77. *Native gold* is ſeldom quite pure, but contains moſtly ſome ſilver; yet the *waſh gold* more than that which is found in veins and cliffs.

§ 78. *Gold*

Gold § 78. *Gold garnets*, ſo called, are properly nothing but a blackiſh iron ore in grains, being even attracted by the magnet. They are moſtly found in the ſurface of earths called *mould*, and in German, *damm-earth*; and if ever they contain gold, it is hardly ſo much as to defray the charge of extracting it. Oftentimes there is mentioned an ore, by the name of *gold marcaſites*, yet they are commonly nothing but a ſulphureous pyrite of a cubical texture.

Nota. Lately theſe grains, called gold garnets, have been found in Saxony, in a common talcy rock, in great quantity.

Of Silver Ore.

Silver § 79. *Silver* is moſt frequently found native and malleable in ſeveral forms and ſhapes, ſuch as like hair, wool, leaves, ſcales, wire, &c. whence it has the names of *cappillary*, *foliaceous*, *laminated*, *arboreſcent* ſilver-ore, &c. It exiſts likewiſe in moſt kinds of common ſtones and earths, and in moſt ſands; it appears alſo upon coloured cobalts, vitreous ores, red ſilver ore, iron-ſtone, and tin-grains, called by the Germans, Zwitter.

§ 80. *Native Silver* never contains any gold; whereas native gold is ſeldom without ſilver. But the native ſilver is reputed to have an admixture of arſenical particles.

Gooſe ſilver-ore § 81. *Gooſe ſilver ore*, (ſo called from its exact likeneſs with the gooſe dung,) is a marle-like, pale and browniſh, very rich glebe, and often ſurrounded and interwoven with filaments of native ſilver.

silver. The same name is given to another sort of Silver
a greenish grey silver mineral, having nearly the
same colour of that dung.

§ 82. *Vitreous silver ore*, is mostly of an uncertain Vitreous
irregular form, representing a mixture of cubical, silver-ore
octangular, &c. figures. It holds only silver and
sulphur. When pure, it may be cut and hammered almost like lead; but if intermixed with heterogeneous particles, it is crumbling, yet these small crumbles are still malleable. There is a kind of vitreous ore, quite brittle, which may arise from arsenic. The colour of vitreous silver-ore inclines more or less to blackness, and there is even a sort quite of a grey colour, very near in appearance to that which has the name of grey ore, differing only from it in that this contains no copper; nor can it be reckoned to red silver ore, because it does not redden when scraped. Wherefore it must take its place among the vitreous ores, because it consists of sulphur, a great part of silver, and some arsenic. The vitreous ore kinds differ indeed with respect to the quantity of silver they contain, yet they are always rich of that metal, holding about three fourths of silver in weight. It melts in the fire so soon as it begins to redden.

§ 83. *Horny silver-ore*, is malleable like the for- Horney
mer, and as easy to be cut. Some is whitish, some silver-ore
yellowish, some dark brown. It seems to be composed of very thin plates, and is semi-transparent, almost like horn, whence it has the name. In the fire it yields an arsenical and sulphureous smell, and holds commonly about two-thirds of silver.

Its

Silver Its outside generally looks dirty and rusty, but by cutting and bending it is easily discovered.

Red silver ore. § 84. *Red silver ore* is also rich in metal: often it is of a high transparent red, but commonly of a deep colour like blood, which latter is often stained over with a dirty lead-colour, but discovers its red colour upon scraping. It may be distinguished from cinnabar, by the latter approaching more to a brick red, whereas the red silver-ore is either of a deep garnet red, or ruby, or a pale red. There is nevertheless some found, though scarce, which is of a pale brick red, very like the cinnabar; but then it is easily discovered in that the cinnabar ore grows brighter the finer it is grinded, but this the duller the more it is rubbed. It is of various forms, often prismatic, hexagon, &c. and frequently sunk in its matrix like another stone; but when in shootings like chrystals, transparent, and of a beautiful red, then it is reckoned very fine and rare. It is very ponderous, and melts in the fire before it grows red hot, and then it emits a thick smoke, which proves by the smell to be arsenical, whence it has its ponderosity. Although it consists mostly of silver and arsenic, yet it may have its red colour from an admixture of sulphur; (§ 49.) and this existence of sulphur in it may be discovered by its deflagration with nitre: for neither silver nor arsenic produces this effect, as the latter being melted with salt-petre causes only a noisy ebulition, which decomposing the nitre, its acid spirit is set at liberty and flies off, but no inflammation ensues. That of an high red colour holds commonly from 60 to 63 ounces of silver the centner. That of the deep red, is uncertain, and holds often some iron. *Red silver-ore* is found with

with the testaceous cobalt ore, likewise with lead- copper- antimonial- and even upon tin-ore, when a silver vein joins with these. Lastly, as for the native cinnabar, which is of a foliated texture, the artificial which is of a capillareous, and the red antimony, which is of a striated texture, red silver ore may likewise be distinguished from these, only by inspection. Ores

§ 85. *White silver ore*, has a light or pale grey-colour. It is heavy and brittle. When pure, it contains 98 ounces of silver in the centner, yet more copper than silver. It consists of silver, copper, arsenic, and sulphur. Some sorts, of a higher colour than this, hold likewise iron, and then only about two ounces of silver in the centner. It must be well distinguished from the light cobalt, being very much of the same appearance, yet the cobalts are always a great deal whiter when broke, and do, besides this, incline, like the bismuth, to a reddish or yellowish hue. White silver ore

§ 86. *Grey ore*, is reckoned among the silver ores, though it belongs rather to the copper ores. Its colour is dark grey. It breaks among or near the copper-ores, or copper-marcasites, and is sometimes mixed with it. It contains from three to twelve ounces of silver. In some places it is called *black ore*. Grey ore

§ 87. *Feather ore*, consists of the smallest capillæ very like feathers. It is commonly of a black colour, and contains two ounces of silver in a hundred weight, besides the sulphur and arsenic; for it produces orpiment, (rauschgelb) § 29. Feather ore

§ 88. *Soot*

Silver Soot ore

§ 88. *Soot ore*, consists of a fine soft black dust, and is very rich in silver, viz. from fifty to sixty ounces in the quintal. It lies commonly in clifts and among the shootings of quartz.

§ 89. Besides these and various other kinds of *silver ore*, it frequently happens that silver is found in the *ores* of *copper*, *lead*, *tin*, *iron*, upon *blend*, in the yellow, brown, and red *ocher-earths*, in *letten**, and *guren* †; likewise in brown, black, and blue horn-stones, and even in the stratas of the common rock: (called by the miners, stein geshiebe) and though they present the silver neither in its native form, nor in any kind of mineral texture, yet have sometimes been found to prove very rich of that noble metal. Whence it may often be very useful to try fossil bodies upon silver, though they have no appearance of it.

Of Copper-Ore.

Copper

§ 90. Copper-Ore, is seldom observed to have any regular form, tho' it is not always quite irregular, as may be seen in the *green striated ore*, and likewise in a sort of *vitreous red copper-ore*. If various fine colours, especially blue or green, appear upon an ore, it is a pretty sure sign that it holds copper: No other ore shewing itself with so manifold colours as the ores of this metal. *Copper-ore* is almost without exception mixed with some iron, of which

* Which is a marl or clay running along on each side of the veins.

† Which is a miner's term, signifying a soft, fattish matter, bubbling and fermenting out between the cliffs and chinks of the vein.

which the more it contains the brittler it proves to be. Copper-ore is ſcarce found without containing ſome arſenic. Copper

§ 91. *Native-Copper*, is often found both in a fluid ſtate, and in a ſolid metalline form. In the fluid ſtate it preſents itſelf in the *Copper-vitriol waters*, wherein nature has diſſolved the copper by means of a vitriolic acid, and from thence it may be precipitated either by nature, or by art. In the firſt manner, the ſolution condenſes in time and forms *native-copper**. In the other, by art, the copper is obtained from thoſe vitriolic waters by means of iron, which being put in and left there for ſome time, precipitates all the copper in its native form. For, the vitriolic acid having greater affinity with iron than with copper, inſtantly ſeizes upon that, diſſolves it, and lets the copper fall down in its metallic form, which collecting in the ſame place, which the iron compaſſes, takes exactly the ſame figure as the piece of iron had when immerſed. This phenomenon has cauſed the ignorant to believe, that iron has been tranſmuted into copper. This copper is called *cement-copper*, and the water producing that effect, *cement-ſprings*. Native copper Cement copper

§ 92. *Native Copper*, in a ſolid body is found,

a. Upon hard ſtones, as ſpar, quarz, ſlate, common rock, and in the fine as well as coarſe ſand ſtone.

* The phyſical cauſe of this is always an irony earth or mineral, by which the copper is precipitated in its metallic form.

b. In

Copper

b. In clefts and fissures.

c. In and upon these chrystalline shootings called by the miners *drusen.*

d. In copper ores, green feather ore, vitreous copper ore.

e. By itself without any visible admixture*.

Red vitreous copper ore

§ 93. *Red vitreous copper ore*, has a red and sometimes shining colour, but is seldom of an angular form. It is the richest among copper ores, and often consists of native copper.

Common vitreous copper ore

§ 94. *Common vitreous copper ore*, called by the Germans, *copper glass*, is a dark grey shining ore, very rich of copper; it must be very well distinguished from another ore called grey ore, which we have mentioned among the silver ores, and contains several pound weight of sulphur, some little arsenic, some pounds of copper, a small portion of iron, and from one to twelve ounces of silver in the centner, wherefore it is placed among the silver ores (§ 84). Its colour is lighter than this *vitreous-ore*, with a yellowish hue, whereas the *copper-glass* inclines to a blue and reddish cast, and sparkles with various red and pale blue colours, which the *grey-ore* never does. It is very ponderous. but not very hard. It contains from fifty to eighty pounds weight of copper in the centner, besides some iron, sulphur, and arsenic.

*. But this is more likely a copper precipitated by nature from vitriolic waters. (§ 91.)

§ 95. *Brown*

§ 95. *Brown copper-ore*, called likewise *liver-ore*; this is hardly distinguishable by mere inspection from some sorts of iron ores, unless discovered by its verdigrease. It is very rich and contains sometimes native copper. Copper Brown copper-ore

There is another sort of it, which is of a looser and lighter substance, and more inclining to a yellowish colour.

§ 96. *Blue copper-ore*, of this are several species, viz. Blue copper-ore

1. *Lapis lazuli*; which is of a beautiful blue, changes not its colour in a moderate fire, is pretty hard, and takes a perfect polish.
2. *Azure copper*; this is of as fine a blue as the former, but too soft for being polished, and loses its colour in the fire.

   This contains among all copper ores the least iron, arsenic, and sulphur, and yields therefore, with the least labour, the best copper, and in the largest quantity.
3. *Mountain blue*; is a light, dusty, earthy mineral, nearly of the consistence of chalk; its colour, as well as its metallic substance and fusibility, is of various degrees; sometimes it is brought by water, where it collects and adheres at convenient places.

§ 97. *Green copper-ore*, is called also *malachit*, when of such a hardness as to admit polishing. Of this the centner contains from ten to fifteen pounds copper. But if soft and earthy it is called *mountain-green*, or *copper-green*, and lies sometimes on the surface of copper-ores, sometimes upon any other ore, as lead, or tin ores, and even upon common stones and earths, where it is brought by water Green copper-ore

Copper water in clefts from copper veins, often very distant from that place, being deposited upon the surfaces of these bodies, by which they are stained green. To this kind belongs that native mineral-colour, called *Spanish-green*, or *green feather-ore*, which is of a beautiful colour, and of a striated texture within. Sometimes it is interspersed with native copper.

Pitch-ore

§ 98. *Pitch-ore*, so called from its appearance of a dark pitch, or rather of a glossy metallic scoria. It is rarely found, and must not be confounded with the sea-coal, or slate like copper-ore. Another mineral known by the name of *copper-black*, might be placed to this kind, it being a fine black powdery substance arising probably from the same mineral, and being pretty rich of copper.

Marcasitical copper-ore

§ 99. *Marcasitical copper-ore*, called by the Germans, *Copper-kiess*; is the most common of all the copper-ores. Some call it *yellow copper-ore*. It is both without and within of a uniform yellow, gold, or brass colour, with a very pale greenish cast. But the more it contains arsenic, the paler it is; therefore its pale colour does not infer always that it is poor of copper. Sometimes its surface and fissures are covered with the finest variety of colours, such as blue, purple, red. It consists of copper, a good deal of iron, and of sulphur and arsenic. If richer of iron than of copper, it goes among the iron-pyrite, or marcasites, but its greenish cast, and much more the verdigris about it, always prove the existence of copper therein. The pale copper marcasite or pyrite, do not strike fire with the steel, as the pale iron-marcasite or pyrite do, provided you avoid the flint and quartz mixed

mixed with it. When a pyrite (*kieſs*) is cubical or circular, of a ſtriated texture, or if it crumbles in pieces when expoſed to the air, it is a ſign that it contains little or no copper. **Copper**

§ 100. *Copper-nickel*, contains ſometimes a good deal of copper, but this ore being commonly mixed with cobalt, the unmetallic earth of which renders its working very difficult and unprofitable, it is moſtly placed among the arſenical ores. This is probably the ore of which Cronſted makes a new ſemi-metal, called *nickel*, which is nothing but a mixture of iron, arſenic, cobalt, and a little copper. **Copper-nickel**

§ 101. When one or more ſorts of the above-mentioned copper-ores are found in a ſlate, it takes the name of *copper-ſlate*. Its richeſs in metal is very uncertain, as well as its fuſibility in the fire very different. Whence ſuch ores, though they may contain but two pounds of copper in a centner, are in ſome places found anſwering the labour and expence of being worked for copper, for their great fuſibility. **Copper-ſlate**

Of Iron-Ores.

§ 102. Of all metals *iron* is found in the greateſt plenty; very few ores are without ſome part of that metal, and may eaſily be diſcovered therein. Thoſe ores which yield good iron, are called *iron-ſtone*, all the reſt which contain but a ſmall quantity of that metal, go by the name of *iron-ores*. **Iron**

§ 103. *Iron* is never found native in its metalline form, or at leaſt very ſcarce; unleſs ſome kinds of

Iron

of sand and of iron-stone, which are attracted by the magnet, and particularly a certain sort of cubical and octangular dice-ore, might be called native iron, yet they are wanting the principal characteristic of a metal, malleability.

Magnet

§ 104. *Magnet*, or *load-stone*, gives often a considerable quantity of iron. Its figure is uncertain, sometimes it is found octangular, but very seldom. When pure, its colour is black, dark brown, and sometimes reddish. It is frequently mixed with flint or spar, which renders its quality worse. Its particular and wonderful properties are treated of by the authors of Natural Philosophy.

Grey shining iron-stone

§ 105. *Grey shining iron-stone*, has almost the colour of iron itself, and sometimes its texture appears to be composed of small and very smooth plates of a greyish iron colour, but often the form of its particles are not distinguishable. This latter sort is more attracted by the magnet, and gives better iron than the former, and more in quantity.

Hæmatites

§ 106. *Hæmatites*, or *Blood-stone*. Its figure is at the bottom convex, but its sides are angular, all which angular edges meet at the top in one point, whence it presents a pyramidical appearance like chrystaline shootings. Its surfaces are pretty smooth and glossy; some, when scraped, turn red, others yellow; when broke in length, its texture presents very regular strya, all which terminate in strait lines into one point at the top. It is very ponderous and hard, whence the artists use it for burnishing metals. It yields much iron, but is commonly of a brittle kind, whence it is only used among other iron-stone. *Blood-stone*

it

it is called from a pretended property of its ſtop-ping hæmorraghes. Iron

§ 107. *Iron-ſtone*, is alſo found of white, grey, yellow, red, brown, dark brown, and black colour, all which yield good and much iron; their form is various and irregular. A blue or green colour is but accidental in theſe ſtones, ariſing often from ſome admixture of copper. A grey or yellowiſh iron-ſtone is commonly of a foliated or ſparry texture, but, the lamina are not ſo regular as in ſpars; and gives from thirty to fifty pounds of the beſt iron. Iron-ſtone

§ 108. *Iron-glimmer*, *rapacious iron-ore*, gives moſtly a brittle iron, yet is made uſe of ſometimes at the iron-works, and the red ſort more than the black. It is a dark, ſhining, ſtriated ore, and beſides iron holds a good deal of arſenic, from whence it acquires that brittleneſs. Iron-glimmer

§ 109. The *iron-ſtone* is found,

1. In ſtratas or beds, near the ſurface of the earth, of various form, ſize, and hardneſs. And this is called *rubble-ſtone*, in German, *leſeſtein*, or *raſen-ſtein:* and when it lies under water in marſhy-land, *marſh-ſtone.* To this kind belong the blackiſh or brown ſands, which in ſome places are worked for iron to advantage.
2. In real ſtocks or neſts, in German, *flötzen.*
3. In regular veins, which often yield the beſt iron.

Iron § 110. Among the *iron-ores*, are commonly reckoned,

a. Magnese, called by the Germans, *brown-stone* which is of a striated irregular figure, and of a grey, black, and sooty colour. It yields but little iron, and that brittle. The potters use it for a black glazing; and the glass-makers to darken the green or blue colour of the glass, and to give it a more solid transparency.

b. Emery, is of a greyish sparry complexion, of a very hard substance, difficult to fuse, and holds but little iron. It may be cleansed from the soft earthy and stony particles with which it is commonly intermixed, by stamping and washing; and then it is used by artificers to polish steel or iron, as likewise to cut glass and precious stones. It is said to contain sometimes tin.

c. Iron-ocher, which is commonly the production of some destroyed iron-ore, especially of yellow pyrites. It is of a rusty colour, sometimes a good yellow paint, but varying in its degrees of shade. It appears often in springs, chiefly in medical-springs, and renders them foul, whence it deposits and collects sometimes in whole stratas. In most places this ocher is found among clays, boles, and marls. Sometimes it is so rich that it may be worked with advantage for Iron.

d. Red-ocher, called by the Germans, *röthel ruddle*. (See § 19) That which is commonly sold by that name, is not a native substance, but usually nothing more than the yellow or red sediments from the making of allum and of vitriol, collected at those works for this purpose.

e. Blend,

e. Blend, commonly called *black-jack*; is very much resembling a lead-ore; it consists of zinc, sulphur, and arsenic, besides a large portion of an unmetallic and irony earth. Iron

This is of late quite struck out from the species of iron-ores, and very justly placed to the zinc-ores.

f. Spuma lupi, in German, *Wolfram*, is a dark-brown striated ore, often of a fibrous irregular texture, but sometimes of a pretty regular foliated dice form; this when scraped turns red.

g. Schirrl, differs very little in appearance from the former, only its structure is commonly prismatic, but it does not redden when scraped.

Neither of these two sorts of ore have, as yet, been sufficiently examined.

h. The *white marcasite*, or *arsenical-ore*, called in German, *misspickel*, or *white kiess*; this is of a smooth surface, white and shining like tin, and mostly of a cubical texture. It contains a large quantity of arsenic, whence it has its ponderosity.

i. Sulphureous pyrite, or *marcasite*, called *yellow-kiess*, This contains more sulphur than arsenic, but both more than half their weight of iron. Its colour is like polished brass.

k. Common marcasite, or *pyrite*, called by the Germans, *yellow copper-ore*, and in some places of England, *muntic*. It contains both iron and copper, besides sulphur and arsenic.

If any of these three last sorts are added to an assay of iron, though in ever so small a quantity, they will certainly spoil the operation.

Iron l. *Lapis calaminaris*, *calamine*, contains a large portion of iron. But since it has lately been discovered to contain chiefly that semi-metal, *zinc*, it takes, with more propriety, its place among the zinc-ores.

Steel § 111. *Steel*, being nothing else or little more than a refined iron, and as steel may be made of iron itself, steel-ore is properly nothing more than a fine sort of iron-stone.

Native-iron-vitriol § 112. *Native iron vitriol*, is reckoned by some among the iron-ores, but we have with more propriety placed it among the salts. (§ 43.)

Flores ferri § 113. *Flores ferri*, *iron chrystals*, which shoot in small branches like coral, are nothing more than a white stalactites and sparry drop-stone.

Of Lead-Ores.

Lead § 114. *Native lead* is very rarely and perhaps never truly to be met with; and these small grains of pure lead, found at Maslau in Silesia, are rather suspected to be either real shot, or arisen from blowing and firing under ground.

Green lead-ore § 115. *Green lead-ore*, is a very rare mineral; it is somewhat transparent, and mostly inclining to a yellowish colour. Its form is often a prismatic hexagon, like chrystals of nitre. Commonly its surface appears somewhat incrustated with an ocher. It is heavy but not very hard, and holds from seventy to eighty pounds of lead in the centner.

116. *White*

§ 116. *White semi-pellucid lead-ore*, is semi-transparent and much of the same appearance and form as the former, except its colour. It likewise bears some resemblance with the glass-spar, but is more ponderous, and the plates which it is composed of adhere more closely together, by which it may be easily distinguished from the spar. Lead White semi-pellucid lead ore

§ 117. A *terrestreous* or *lapidareous lead-ore*, is sometimes found, but not very common. It has the appearance of a fine greyish white argillaceous or marly-stone, interspersed with some small dark grey chinks and yellow spots, and contains from ten to twenty pounds of lead in a centner. The earthy sort is richer than that which is stony. It is the same mineral which in England goes by the name of *coak*. At Selinginskoy in Asia, such a yellowish ore has been found, which, besides lead, holds gold, silver, and antimony. Terrestreous lead-ore

§ 118. In an island, called the Bear Island, a lead-ore has been found, which is of a brownish colour, semi-pellucid, almost like a black resin, and very similar to the common lead ore with regard to its cubical texture.

§ 119. The cubical *potters lead-ore*, called by the Germans, *bley-glantz*, is the most common sort of lead-ores. It is composed of very thin, smooth, steel-coloured, shining leaves or plates, so placed one upon another as to form cubical figures like dice. It is very weighty, brittle, and more fusible in the fire than other ores. Some sorts of this ore contain six and more ounces of silver in an hundred weight; others very little, and some none at all. Yet this is intirely accidental, and nothing Potters lead-ore

can

Lead can be judged of its contents of ſilver with certainty by mere inſpection*.

§ 120. When a lead-ore is ſo finely grained that its texture cannot be diſtinguiſhed by the naked eye, then it is called in German, *bley-ſhweif.* When it repreſents leaves it is named *flowery lead-ore*; and when veined or radiated, *ſtar grained lead-ore.*

§ 121. This *potters lead-ore, (bley-glantz,* § 119.) muſt not be confounded with the rapacious iron-ore, called by the Germans, *iron-glimmer*, (§ 108.) neither with *blend*, nor with *antimony*; for it bears ſome reſemblance with all theſe three ores. But *iron glimmer* is of a blackiſh blue, *blend* of a much darker and by far not ſo ſhining a colour, and *antimony* of a more bluiſh deeper caſt, and makes itſelf chiefly known by its ſtriated texture. However, when this lead-ore is compared with thoſe, it muſt be done with a piece freſh broke, for when it has been a long time kept in the air and duſt, its outſide grows often ſo dull, as to appear very like *blend.*

§ 122. Sometimes this lead-ore (§ 119) is ſo much interſperſed among ſtones, earths; or marcaſites, as not to be diſtinguiſhed without a microſcope; which circumſtance has produced many falſe notions of new lead-ores, and even common

* However the miners make it a rule, which is pretty well confirmed by experience, that when the grains or cubes are ſo ſmall that they look like ſmall ſparks, it commonly is the richeſt of ſilver, and to this they give the name of *ſmall grained lead-ore*, by which the ſteel-grained lead-ore, may be meant in Engliſh.

lytharge

lytharge has been given out for a particular new kind of lead-ore.

§ 123. Lead-ores become more fusible in the fire by the addition of iron-ores or even of sulphureous pyrite, whereas other ores are rendered more refractory by this means. So iron itself, or the richest scoria of it, will make a very proper addition in the fluxing of lead-ores. For as iron readily unites with the sulphur, but never mixes with the lead, it quickly frees the ore from all sulphureous matter, and leaves the lead to flow and separate freely in its pure metalline form.

§ 124. Both lead itself, and the common lead-ores, are of great service in the melting of such refractory ores which contain gold and silver.

Of Tin-Ores.

§ 125. *Native tin*, is no more to be found than native lead. For that which has sometimes been produced for native tin, in the working of tin-mines, has really been melted by forcing the veins with fire and gun-powder, and must not be mistaken for a metal thus formed by nature. Tin

§ 126. *Tin-grains*, in German *zin-graupen*, are of an angular and mostly irregular figure; whereas that which is called *grained tin*, and by the Germans *Zwitter*, is an ore with very little or no appearance of angular particles. Tin grains

 § 127. *White*

White tin grains

§ 127. *White Tin-grains*, are very heavy, semi-transparent, and in appearance similar to spar. Those very white sorts, from Slakenwalda in Saxony, upon the borders of Bohemia, are said to contain no tin, but only some iron. There are likewise yellowish, brownish, reddish, and black tin grains. *

Grained tin

§ 128. *Grained-tin, (Zwitter)* is as variously coloured as the former, but commonly mixed with other stony particles. When burnt, stamped, and washed, it is called *black-tin*, by the Germans *tin-stone*, and then it yields about two thirds of pure metal. The rest appears, by its smell in the fire, to be arsenical, from whence this ore acquires its ponderosity; tin-ore being, like all arsenical ores, the heaviest of all, though tin is the ligtest of all metals.

§ 129. As tin-ore does not fly when suddenly thrown in the fire, so as other ores and stones do, this circumstance has furnished a very easy method of examining whether a mineral stone contains tin, and how much in quantity. For, if a small iron plate or shovel be made red-hot, and some of the suspected ore be pounded very small, then spread thinly upon the hot iron, so that every part may be instantly penetrated by the heat, the stony and other particles will immediately crack away, while the tin-ore remains unmoved in a grey reddish powder, stained over with an arsenical fume.

* There is a sort of those tin grains found in Saxony, whose colour is of a dirty white, and are interspersed within side with gold yellow spots, as bright as the finest leaf gold.

OF

Of Mercury.

§ 130. Mercury is found in its native fluid form in some places, where it partly presents itself in small visible globuls sticking in a loose slaty ash coloured kind of stone, or in a soft marl or clay; partly it runs out of its receptacles so as to be collected by vessels. And this is called *virgin-mercury*, because it has not been in the fire. **Mercury**

§ 131. The only ore of mercury hitherto known is *native-cinnabar*. This is of a fine red colour with a glittering lustre and some times transparent. It is very heavy but not much harder than chalk, and contains from one fifth to one seventh of mercury, besides one, two, or three-eighths of sulphur. It may by its foliated texture easily be distinguished from *factitious cinnabar*, which is fibrous or striated. The mercury and sulphur are in this ore so intimately united, that they sublime together in the fire, and may not be separated but with the assiststance of some substance which has greater affinity with the sulphur than with mercury. **Native-cinnabar.**

§ 132. A mercurial ore is found in Hydria, where the mercury lies in an earth or stone as if it were in a dead form, and has the appearance of a red-brown iron-stone, but is much heavier than that. It contains three quarts, to seven eights of the purest mercury, leaves after the distillation a very black strong earth behind, and gives some marks of cinnabar. This mineral however seems not, with that property as we have given, (§ 68,) to be called an ore, but may rather be placed to the native

Mercury native mercury,(§ 130.) For as microſcopes magnify no farther than to a certain degree, and as we do not know the ultimate diviſibility of mercury, we cannot juſtly determine the point of its fluidity, although its globuls may no more be diſcernable; beſides, mercury may change its fluid form alone with fire without adding any other means, and yet remain a live quickſilver; for by the aſſiſtance of fire only it is to be converted into a powder, which, with a ſtronger fire ſhall recover its former fluid ſtate.

§ 133. Of all minerals, *mercury* is found in leſs quantity than any: It having been obſerved that many times more gold is found annually, than mercury; which probably has been ordered ſo in the courſe of nature, from its little uſe in human life. Though perhaps another reaſon of that ſcarcity may be the careleſſneſs or inexperience of thoſe who try minerals. For commonly theſe trials being made in open veſſels and ſtrong fires, no regard is had to what flies off in fumes, but only to that which remains in the pot. Wherefore minerals in general ſhould be examined more carefully, and eſpecially in cloſed veſſels; which undoubtedly would produce many uſeful diſcoveries, which by the preſent neglect remain unknown.

Of Antimony.

Antimony § 134. Antimony is that ore out of which its *regulus* is made, and conſiſts of that and of ſulphur. *Native regulus of antimony* is ſcarcely known. However it is ſaid to have been found by one Antony

Antony Swab, in a mine in Sweden, called Salber's mine, of which an account is given in the Transact. of the Royal Academy of Sciences of Sweden, printed at Hall, 1748. The *common* black-grey, or blueish *antimony* is most usually of a striated texture, yet there is some found without any certain form: And in that case it may easily be mistaken with the small grained lead-ore, with white silver-ore, and with iron glimmer; but the way to distinguish it immediately from these, is, to hold only this ore in a burning candle, because the antimony will melt in that little heat, which none of the other ores does; yet an expert eye may readily discover it by the colour. *Purple-antimony* is but rarely found; it is of a delicate fibrous texture, consisting of regulus, sulphur, and some arsenic. Antimony

§ 135. *Crude-antimony*, is not only that which is separated and picked out in compact pieces from the stony and other heterogenous matters of the ore, without fire, but also what is melted out of its mineral stones and earths by fire. This ore has indeed its own regular veins like other minerals, though they run more near the surface of the earth than in great depths, yet other kinds of ores are sometimes found along within its veins. Crude antimony

Of Zinc-Ores.

§ 136. As the production of *zinc* from its ores was formerly entirely unknown, the existence of *zinc-ore* has always been doubted, or rather entirely deny'd. Some have even imagined that this semi-metal was only an excrescence of lead, or of other metals. Zinc

Zinc metals. At the Harz zinc is collected merely by accident in the ſmelting of other ores. But where and in what manner the Eaſt India zinc is made, we have no certain advice. Its colour is more inclining to blue, and it is tougher and purer than the German zink.

§ 137. Since lately a method has been found out of extracting zinc from its ores, we can now name ſeveral ſorts of real zinc-ore.

Calamine § 138. *Calamine*, or lapis calaminaris; this was the only mineral ſuſpected of being a zinc-ore, becauſe it gives in the fire that white wool-like calx, called *flowers of zinc*, and converts copper into braſs, like zinc itſelf. But the method of reducing that ore into a real ſemi-metal, was either not known or kept a ſecret, till lately made public. This ore has no regular form; ſometimes it is ſoft and friable like earth, ſometimes compact and harder than a ſtone. Its colour is various, ſuch as grey, pale yellow, reddiſh, &c. If thrown in ſmall pieces into a ſtrong fire, it colours the flame inſtantly of a violet blue, like the zinc itſelf, and emits a thick ſmoke, which however ſmells neither of ſulphur nor of arſenic, but if any thing it is of an aſtringent nature; and if theſe fumes are caught, they collect in very ſoft and light flowers cohereing together in a looſe ſubſtance, and appearing firſt of a bluiſh, but changing afterwards into a greyiſh-white colour.

Blend § 139. *Blend*, called in ſome places, in Engliſh, *black jack*, contains, beſides iron ſulphur and arſenic, a part of zink, and takes therefrom its place among

among zinc-ores. There is a reddish sort of this ore, which, when rubbed becomes phosphoric in the dark, and is rather richer of that semi-metal than the other.

OF BISMUTH.

§ 140. BISMUTH is always found in its true semi-metalline form, and, like the gold, never to be met with in the state of an ore. But when it is surrounded with various heterogenous and stony matters, and chiefly with cobalt, as it is often the case, so as not to be very visibly to the naked eye, then it is called *bismuth-ore*. *Bismuth* is most commonly lodged in cobalt. *Bismuth-bloom*, or *flowers of bismuth*, it is called when the mineral stone presents this ore in a high-red, or peach-blossom colour, and when melted produces bismuth. **Bismuth**

§ 141. It was formerly believed, and some are still of opinion, that bismuth gives to glass the same blue colour as the cobalt does; because experience proves that the dross which remains after the bismuth has been melted out, which the smelters call *bismuth grain*, produces really that effect with the glass: But as no such grains or colouring earth remains from pure and solid bismuth, it is plain that this quality must arise from something mixed with the bismuth, which undoubtedly is nothing else but cobalt (§ 67.) **Bismuth-grain**

Arsenic

Of Arsenical Ores.

Native

§ 142. Of *native arsenic* there is properly but two sorts:

a. *Testaceous cobalt*, which is of a semi-metalline form, and has, when broke, a blueish-white, glittering appearance: and

b. *White arsenic*, which is either found in chrystals, or lies in the form of a mealy substance among the chrystalline shootings of spar.

That which goes by the name of *yellow* or *red arsenic*, is no more a pure arsenic, but has always an admixture of sulphur.

§ 143. When the *testaceous cobalt* is pure, it sublimes wholly up in the fire, and collects either in the form of a white flour or meal, and even in transparent lumps; or else in a shining metalline appearance. Sometimes it contains silver, which is perhaps but accidental; though there is some of that ore found interwoven with solid native silver.

Orpiment

§ 144. *Orpiment*, *auripigmentum*, is of a foliated slaty texture, in some degree friable, yet of a pretty tough consistence: it glitters upon being broke, and its colour is of a gold-yellow. Sometimes *native sandarac* is found in it, called in German *rauschgelb*, and makes itself known by its cinnabarine colour. It consists mostly of arsenic, and some part of sulphur, besides some earthy substance, and therefore burns in the fire with a dirty white blueish colour, and raises a strong white smoke. Red, compact, or chrystalline arsenic is likewise found

found sometimes in small long pieces upon this orpiment, as well as upon the testaceous cobalt, &c. Arsenic

§ 145. The *white marcasite*, called by the Germans in general *white kiess*, and at Freyberg, *misspickel*, but in the upper mountains *arsenical pyrite*, (*arsenic-kiess*) consists of arsenic and iron only. *Tinn-grains* contain one fourth to one third, and *red silver-ore* to one half its weight of *arsenic*. *Common pyrite*, *yellow copper ore*, called mundic, *grey ore*, *white silver ore*, and indeed most all silver ores, contain all a great deal of arsenic; except the vitreous-silver-ore when pure, and the pure cubical lead-ore. White marcasite

Of Cobalt Ores.

§ 146. *Cobalt* is either found of a fine striated texture, or else granulated with a smooth surface. Its colour is often light-grey and shining like a semi-metal, but sometimes dark and blackish. It contains a great quantity of arsenic; and when that is driven out by fire, there remains a fixed earth, which being fused with glass, gives it a beautiful blue colour; and then it is called *smalt*, or powder-blue, when reduced into a fine powder. This mineral is the only substance in which that colouring earth has been found. A certain arsenical ore, from the mines of Halsbruck or Lorenz Ggenthrum, near Freyberg, and some other mineral stones, the intrinsical nature of which has not yet been examined, have frequently given the name of cobalt, but falsely. Cobalt

Cobalt

Cobalt-bloom § 147. *Cobalt-bloom*, or *flower of cobalt*; it grows upon the cobalt like an amianthus, and is a fine, fibrous, ſtriated ſubſtance, reſembling the flowers of antimony, and ſhewing a beautiful purple colour on the ſurface, ſomething like red ſilver ore, but within ſide it is all of a grey or pale lead-colour. But ſince from this mineral the arſenic ſublimes in as large a quantity as from the cobalt itſelf, and the remainder has the ſame quality of colouring the glaſs blue, it is certainly nothing elſe but a true cobalt, though it appears only as a ſubſtance growing upon the cobalt. It reſembles very much the peach-coloured biſmuth-bloom; ſo as indeed cobalt and biſmuth are frequently found in the ſame mineral together. Laſtly, another certain mineral is ſometimes found upon a compact cobalt, in the form of a ſoft, looſe, powdery ſubſtance, which is called *cobalt-mould*, by the Germans *cobalt-beſchlag*.

§ 148. The form of *cobalt* is very uncertain; often it is angular, ſometimes granulated; frequently it appears as if compoſed of ſcales or thin plates; and at other times it has only the form of a metalline ſcoria: From whence it has given various names, ſuch as *granulated*, *flocky*, *ſcoriated*, *knit-cobalt*, &c. It oftentimes contains ſilver, and the richer it is of that metal, the more heterogeneous parts it abounds with, and conſequently the worſe it is for colouring glaſs blue.

Copper-nickel § 149. That ſort of marcaſite which is commonly called *copper-nickel*, is likewiſe a pooriſh kind of cobalt. Its colour is of a reddiſh grey, and

and shining; it contains, besides a small portion of sulphur and copper, a large quantity of arsenic.

Of Sulphureous Ores.

§ 150. *Sulphur* (§ 29.) is sometimes found *native*, but mostly in ores. The first presents itself either in solid pieces, and are sometimes transparent, or lies in earth and stones, which appear as if glazed over with real sulphur: or else it is brought by water, especially by medicinal springs, where it adheres and collects in various forms, but most frequently resembling blighted corn-ears. **Sulphureous ores**

§ 151. Among the *sulphureous ores* might indeed be reckoned, in some measure, antimony, cinnabar, and most part of silver, copper, and lead ores: but as the sulphur, in most of these ores, would not defray the expence of extracting, nor could it be obtained pure from the antimony without some proper additional ingredients; and as in all these ores the metal which they contain makes the principal object; besides that the sulphur in some, such as the lead ores, makes a very needful ingredient as a menstruum for dissolving other refractory ores in fusion, and to bring the metal into that first rough regulus, called by the smelters, rough-stone: the only mineral usually allowed the name of a sulphureous ore, is the *common* or *sulphureous pyrite*, comprehending likewise the *yellow copper ore*. Those pyrites are of a yellow gold colour, and shining within and without like

a polished brass; but with respect to its form, it shews itself in so many shapes as no other mineral does. Its characteristic property is to strike fire with the steel, and consists of one-fourth to one-third of sulphur, besides some iron, and an unmetallic earth. See a complete account of it in *Henckel's Pyritology*.

Of Vitriol.

Vitriol § 152. There are three sorts of *native vitriol* found, as mentioned § 42. But pure copper-vitriol, or such as contains more copper than iron, is never found; because copper-ore alone, without an admixture of iron, can never turn into vitriol. But *pure*, *native*, *iron-vitriol*, is found in Hungaria; and the *native white*, or *zinc-vitriol*, in the mines of the Harz.

Atrament stone § 153. Those stones which contain a perfect vitriol, are called *atrament-stone*, or inck-stone, and vary much with respect to weight, hardness, and colour. Some are black, grey, yellow, or red: but these colours being only accidental, make no difference in the vitriol produced.

§ 154. From the marcasites or pyrite, vitriol may be obtained:

a. Alone, only by exposing these ores to the air, which raising a fermenting motion within their particles, produces an expansion of their bulk, which makes them crumble in pieces; and then their surface appears covered over with

with very fine capillareous fibres, which are the real vitriol in the form of very small chrystals: Vitriol

b. By art: which is done with roasting and burning these pyrite before being exposed to the air.

With the first method, the common sulphureous, irony pyrite succeed best; but copper-pyrite, (muntic) and those which contain much of arsenic, must be treated in the other way, with roasting.

§ 155 *White vitriol*, called by the Germans gallizen stone, is produced from zinc ores, and not from lead ores, as hath been erroneously supposed. For, notwithstanding this white vitriol is made at Goslar from a marcasitical lead ore, by preparing it with a long-continued roasting fire; it is however very certain, that it arises from nothing else but the zinc contained in that ore; partly, because this white vitriol contains a real zinc, partly because this marcasitical lead ore is commonly very much mixed with *blend*, of which we have seen above to be a zinc-ore. White vitriol

§ 156. *White* as well as *green vitriol*, may be made from most sorts of *calamine*, because it contains both iron and zinc; but it requires first roasting.

Of Alum.

Alum

§ 157. *Alum* (§ 41) is either *native*, so as to require only of being elixivated out of its mineral matrix; or it is contained in certain mineral bodies, which must be prepared by fire and air. Some must be treated with roasting in an open gentle fire, as calamine. Others are merely expoposed to the air, in large heaps, where they soon begin to ferment, to grow warm, and at last even to inflame, when they yield an offensive bituminous, and sometimes sulphureous smell, and then crumble into a loose and almost insipid earthy substance. But this preparation requiring but a gentle fermentation and warmth, because a greater heat would expel a real part of their volatile acid; these heaps, upon growing too hot, must be moistened with water, and spread asunder.

Alum ores

§ 158. *Alum ores*, as they contain no metal, are very improperly called ores; but in compliance to custom, we shall continue that name. Their species are the following:

a. A blackish, slaty kind of stone, found along with the veins of marcasitical ores.
b. A brown, inflammable, bituminous earth.
c. A fat, bituminous slate.
d. A black, shining, bituminous, foliated, and sometimes wood-like mineral, very like the sea-coal, but much lighter.
e. Some sorts of calamine.

Of

Of Salt-petre (Nitre) and its Earths.

§ 159. *Nitre*, as far as may be judged hitherto from experience, is generated only on the surface of the earth; and if any may be found in some springs and waters, it is probably of having been only washed out of nitreous earths, and carried among those by rains. Saltpetre

§ 160. Most earths, especially the loamy and calcareous species, are very proper for the generation of nitre: and such earths may be much farther enriched by the admixture of most kinds of vegetable as well as animal substances, whether they have been already putrified by themselves, or be brought to putrify in those earths.

Of Mineral Waters.

§ 161. When any or several of the above enumerated mineral bodies have united with water, it is named a *mineral water*. If replete with common salt, it has the name of a *salt spring*; if so rich of copper as to admit of being precipitated with iron, it is called a *cement water* or *spring*, and the copper extracted from it *cement-copper*. When such waters are applied to the cure of diseases, they are known by the name of *medicinal waters*, *baths*, &c. Mineral waters

§ 162. If such waters are impregnated with sulphur, they discover themselves by their particular smell, similar to rotten eggs; and those which contain

Mineral waters

contain an iron vitriol, are detected by giving a black colour to a decoction of bitter abstergent vegetables. If copper-vitriol, a polished iron immerged will be covered over with copper, and its colour be changed into that of real copper. If they contain either an acid, or an alcaly, they will soon discover themselves, with the blue juice of vegetables, or by effervescing. See § 27, 28.

§ 163. It is remarkable, that in some mineral waters, both an alcaly and a vitriol is found together in the same time, without having affected each other: for, if such a water effervesces with acids, it can only be from the actual presence of an alcaly; and yet the same water shall leave a yellow ochreous earth when evaporated, which can arise from nothing else but a destroyed vitriol, and proves consequently that it contained also an acid. Whence it may be supposed that the bitter salts of mineral springs do not so much exist therein actually, as being rather produced during their evaporation.

Of

Of the FIRST and THEORETICAL PART.

DIVISION. II

Division II.

Of Chymical Agents or Instruments.

§ 164.

A BODY, which a chymist employs to produce an intended alteration in the subject under his examination, or to be any ways assisting towards this end, is called a *chymical agent* or *instrument*, Chymical agents

§ 165. Whatever change or alteration is to be effected in any substance, it must be either by uniting or discomposing the bodies, or by both at the same time, and consequently by a *motion*; wherefore these agents must either have already obtained that motion, or it must be produced in them by some assistance.

§ 166. We

Chymical agents

§ 166. We have the *ſix* following ſpecies of *chymical agents*:

1. *Fire.*
2. *Air.*
3. *Water.*
4. *Earth.*
5. *Diſſolvent menſtrua.*
6. *Veſſels or utenſils.*

Each of which ſhall be treated of with all poſſible brevity and perſpicuity.

CHAP. I.

OF FIRE.

Fire

§ 167. FIRE is the principal agent in the art of chymiſtry, for without its aſſiſtance no chymical operation can be performed. *Fire* is a body too ſubtle to come within ſenſual contact, like other material bodies: whence it is difficult to aſcertain its nature and properties, as far as they are peculiar to this element alone. All that we know of it, is by ſome of its effects; and that it exiſts in all other bodies and places which come within the reach of our experience.

Its properties

§ 168. The two chief properties of *fire* ſeem to be theſe:

1. *Light*, which it diffuſes equally.
2. *Expanſion*, which the fire produces upon all bodies penetrated or rarified by it.

Both

Both these effects it produces often at one and the same time, but sometimes only one of them is apparent to our senses. Thus, the light of the moon frequently shines very bright, but is incapable of producing a perceptible expansion of bodies. On the other hand, many substances may be warm, or even hot, and only suffer expansion, without giving any signs of light. Properties of fire

§ 169. The second of these properties of fire observable in bodies affected by it, has given rise to the invention of two instruments for measuring the force and degrees of heat. One of these instruments which measures the heat by means of a fluid, such as water, oil, spirits, or mercury, is called a *thermometer*. The other is done by the expansion of a solid body by heat, such as a metalline rod, shewing the degree of heat contained therein; and this is called a *pyrometer*; because it shews the degree of heat in the open fire.

§ 170. Since then *fire* produces an expansion in bodies: or, in other words, as it enlarges their bulk by forcing their interior parts towards the surface; and as this cannot be effected but by motion, we conclude from hence, that the body thus penetrated by heat, so as likewise the fire itself, must be always in motion, because a body may not move another, without being itself in motion.

§ 171 The more particles of fire enter into a body, and the more they are agitated by the motion of another body, the more the motion of that body increases which is thus penetrated by the particles

Properties of fire

ticles of fire, and so the sooner and easier follow the effects intended; for example, fusion, evaporation, &c.

§ 172. Although some of those effects produced by fire, may appear as if contrary in themselves, by separating some substances, and uniting others; yet they may easily be reconciled by considering the motion caused by the application of fire, and the particular properties of the several bodies exposed to its power.

§ 173. The more solid and compact a body is in its substance, the more it resists the fire; and the slower it is in heating, the longer it retains the heat, all things equally considered with respect to time, size, and form.

§ 174. Every matter which is combustible, either wholly or in part, is called the *pabulum of fire. Fuel.* Of which the purest is, *alcohol vini*; next to this, the *distilled-oils*, amongst which may be included *oleum-petræ*, and *naphta*; then *expressed-oils*; after these, *charcoal*; then, *clean-wood*; after this *turf*; then, *sea-coal*; and lastly, the *dung* of some animals.

§ 175. As *fire* produces various effects upon the same bodies in proportion to its different degrees, it becomes necessary to make certain divisions or degrees of the power of heat, and to observe those different degrees by the several operations. Formerly only four degrees have been known; but, for want of necessary instruments, even those could not by far be so clearly ascertained as they

are

are at present by means of thermometers, especially those of Fahrenheit, by which the degrees of heat are specificially determined to fix general divisions. Degrees of heat

§ 176. The *first division of heat*, includes those degrees upon Fahrenheit's scale, from the *first* or lowermost, which is the greatest degree of cold, up to the *eightieth*; within this division all kind of vegetables are generated by nature and kept alive: For, even in the greatest cold the wild mosses will grow upon the bark of trees; so likewise the fir, juniper, and divers other trees and shrubs will retain their verdure through the hardest winter. This division of heat is of great utility in hot-houses, when to each vegetable that degree of heat is given which naturally is required to its growing and maturity. 1st division

§ 177. The *second division* of heat comprehends all the degrees observable at different times in healthy persons; and begins at the *fortieth* and ends at the *ninety fourth* by Fahrenheit's thermometer. As long as the juice of animals enjoy any degree of heat comprehended within this compass, they are able to live; though some fishes have been observed to live in a water that is full as cold as the thirty-fourth degree. It may therefore in general be said that the heat for living and healthy animals, is from the thirty-fourth to the ninety-fourth degree. In this *division* all the vital functions of animals are performed, as also the fermentation of vegetables, and the petrefaction of both: With this heat likewise chymists prepare their elixirs, the simple and volatile alcaline salts, tinctures, and the first operation of their philosophical work. 2d division

§ 178. The

Heat 3d diviſion

§ 178. The *third diviſion* begins at the ninety-fourth and reaches to the two hundred and twelfth degree, in which water commonly boils. Within this diviſion, the water and the natural (eſſential) ſpirits (—∩—) are ſeparated from animal and vegetable bodies: The eſſential oils of plants, ſo called, become volatile, and may conſequently be diſtilled from vegetables, as well as their waters. However the ſalts and oils of the freſh animal juices may not be raiſed in this degree of heat, but will only dry into a thick, hard, and brittle ſubſtance, inſipid both to taſte and ſmell, in which ſtate they will keep for many years unaltered.

4th diviſion

§ 179. The *fourth diviſion* may be reckoned from the two hundred and eleventh to the ſix hundredth degree, within which limits all ſorts of oil will come to boil; ſaline lyes, mercury, and oil of vitriol, will riſe up, and may conſequently be diſtilled. Lead and tin come in fuſion; the oils, ſalts, and ſoaps of animal and vegetable ſubſtances, become volatile, and are rendered more or leſs alcaline; the ſolid parts of theſe bodies grow dry and burn to a black coal, and are therewith entirely deſtroyed, looſe their natural properties, and acquire others. Common ſulphur, and ſalt armoniac will likewiſe ſublime in this heat.

5th diviſion

§ 180. The *fifth diviſion* is limited between the ſix hundredth degree, and that heat with which iron may be brought in fuſion. In this height of heat none of the metals, except gold, will remain unchanged: Silver looſes by a long continuance a ſmall part of its weight, but all other metals are, ſooner or later, totally deſtroyed therein;

All

All other kind of solid bodies grow red and white hot; the fixed alcaline salts, fossil as well as vegetable, are brought in fusion, deprived of their oily substance, and are more and more hightened in their alcaline sharpness. The argillaceous earths burn to a perfect hardness, gypseous-stone burn to plaster; the calcareous turn into lime; the vitrescent-stones, either by themselves, or mixed with other sorts, or with salt, are converted into glass. Heat

§ 181. The *sixth* and last *division* of *heat* is produced by concentrating the sun-beams by means of concave speculums, or with convex glasses: The violence of which no material substance can resist. The least of its effects is, that every metal is instantaneously melted by it, because most all other bodies are reduced into glass. Even gold has been said to suffer vitrification by this means; which however may justly be held in doubt. 6th division

This degree of heat is to be produced by uniting the effect of one or several such convex glasses or speculums, and may be raised to any degree by increasing the number of these instruments, exposing them to the sun, and directing their focusses all to one point. But even here we are unable to set limits to the force of fire, nor is it possible to determine with exactness how much farther its effects may reach.

§ 182. From what has been said hitherto, it appears that there are as various degrees of heat required, as there are different operations in chymistry. It becomes therefore very necessary that every chymist should know how to obtain that degree as is required to each purpose, what fuel produces a stronger

ſtronger fire, and which a leſſer; and likewiſe by what means this is to be raiſed, or leſſened.

Its pabulums

§ 183. *Alcohol-vini*, gives a gentle, but equal heat, and may be increaſed or leſſened by a greater or leſs number of wicks. After this follows the lighter, porous, ſpungy, ſorts of fuel, ſuch as ſtraw, dryed leaves, and the ſtalks of ſome plants. Next comes oil, fat, wax, camphir, reſin, ſulphur, and whatever is replete with the like ſubſtances. But to a ſtronger fire ſerves the black turf, the hard, ſound, and not too dry wood, or charcoal made from it, and pitcoals.

§ 184. Heat will neceſſarily be ſtronger or weaker, in proportion to the quantity of fuel imployed at one and the ſame time. (§. 171.)

§ 185. The nearer the body to be acted upon is placed to the fire, the more it will be affected by it; and the farther it is diſtant, the leſs will it ſuffer from its action.

No certain rules have as yet been eſtabliſhed to determine the proportionable effects of fire upon bodies with reſpect to their diſtance from it; and it ſhould ſeem from ſome experiences, that this is not eaſily to be aſcertained; for, it appears probable that the particles of fire may, at different diſtances, receive various and new motions, either by being cloſer compreſſed, or otherwiſe acted upon by external bodies. (§ 171.)

§ 186. The force and effect of fire may be farther increaſed by the aſſiſtance of another body already in motion. (§ 171.) This may be effected either

either by an agitated air, or by a parabolical structure of the furnace whereby those particles of fire which otherwise would fly off, are drove back again upon the body exposed to the fire. The air may be brought into motion, either by the fire itself, or by machines and other contrivances, such as bellows, water-streams, &c. The larger the bellows are, the greater the velocity they are moved with, and the greater number of bellows are directed to one point, the stronger will be their effect of raising the heat to that body which they act upon. The other way to produce the motion of air by the fire itself, depends upon the expansion or rarefaction of air in the furnace, whence a kind of vacuum arises. The more therefore the air is rarified in the upper part of the furnace, and the cooler the air is kept in the wind-passage underneath, the greater will be the force of fire: and this effect will still be the greater in proportion as the uppermost passages of the furnace are made narrower, and the draught-hole underneath larger. Though this requires likewise its certain limits and proportion. Of fire

§ 187. It may easily be concluded, that the more of these means treated of from (§ 84 to 87) are applied at once to act with united force upon an object, the greater will be the effect in proportion: and if all these means are made use of at the same time, the heat may be raised to a very great degree.

§ 188. *Cold* in general, how it may be considered only as a deficiency or absence of heat, and by what means heat as well as cold may be produced,

of

of this may be seen various accounts in Boerhaave's Chymistry, and several other modern authors of natural philosophy.

CHAP. II.

OF AIR.

Air § 189. THERE is no kind of body known which may be said to be quite void of *air*, neither which could live and grow without it. No material fire, viz. such as is fed by fuel, can exist without air. Since therefore no chymical operation may be done without fire, it follows, that they can neither be performed without air; though it will appear in the sequel, what great influence air has in chymical operations: a chymist ought therefore to know the chief properties and effects of this element.

§ 190. That the air is a body, is proved by its resistance to those bodies which are moved by it. But that it is a fluid body, appears from its agility and divisibility: and this fluidity is so proper and natural to air, that even in the greatest degree of cold it has not been discovered to lose any part of this quality: for, notwithstanding some solid particles are seen flying in the air in an intense cold, upon which we observe the sun-beams to reflect, yet they are not air, but only particles of water.

§ 191. Although

§ 191. Although the particles of air are so small, as to be perfectly indiscernable by microscopes; it appears, however, that they must be greater than the particles of fire, because they do not penetrate any metal, glass, stone, compact wood, nor even a strong solid paper; and what is more remarkable, not even the pores of some bodies which other fluid matters can penetrate.* Properties of air

§ 192. The particles of air readily unite themselves with certain other bodies, or attract one another, as for example, water. For, when the air has been extracted from water, the same water, when exposed again to the air, will in a little time be impregnated again with as much air as it was before. Or, if a bottle is filled with such water from which the air has been extracted, and but the smallest part of air left in it, and this bottle with the mouth turned downwards is put into water, so that the air bubble appears on its surface in the glass-bottle, this air-bubble diminishes by degrees, and disappears at last entirely, leaving the bottle quite filled up with water; so that consequently the air has again united and mixed with the water. is attracted by water and attracts the water

Upon this appearingly insignificant experiment, depends a very great and useful operation, called the graduating of salt-water, or salt-springs. For,

* This may, however, admit of a closer examination; as this resistance of bodies may only be apparent, and not in all respects real; and as at least other fluid matters may certainly not pervade these bodies without a reasonable portion of air; besides that this would be a direct contradiction of § 189. See likewise (§ 207.)

Air. whilst this salt-water or soda falls down through the air in small drops, the air attracts a considerable part of them, and renders therewith the soda thicker and richer, so that then it may be evaporated by fire with more advantage in the making of salt.

Weight of air. § 193. The art of weighing air has been discovered but about two centuries ago; and since that time natural philosophers have established the same upon such infallible principles, as to be clear of all doubt.

Since then the earth is surrounded on all sides with air, constituting therewith what we call atmosphere; and since two ponderous bodies, by touching closely each other, produce a pressure, the air must needs press with its weight upon the earth, and all the bodies upon it; and this effect, being a fluid body, (§ 189) must take place above and below, and on all sides, with equal force. Its weight in proportion to water is nearly as 850 to one; that is, the water is 850 times heavier than air; and so it is when the thermometer is at its mean height, and at the medium of warmth of our atmosphere. Upon this pressure or weight depends the sucking of pumps in water-engines, and the effect of the sucker. However, this weight proves, with respect to various times as well as to different places, of more or less force; that is, the higher the place is situated, the lesser,—and the lower the place, the greater is that pressure or weight of air.

§ 194. Air

§ 194. Air may be compressed into a smaller compass by the force of a weight; and when this weight is removed, it expands again to its former extent or circumference. This property of air is called *elasticity*, which is so peculiar to air alone, that nothing of the same property has been discovered in any other fluid body. For, though water, oil, spirits, and lies may be expanded by heat, and contract again when cold to their former bulk, yet they may by no means be compressed with any weight or force, so as to shew the least expansion after the weight has been removed. Elasticity of air,

§ 195. Certain rules have been discovered, whereby it is determined how far the air suffers expansion and compression. It is this: that the space or bulk of the compressed air diminishes in the same proportion, as the pressing power or weight increases, and expands again in the same measure as the weight is lessened: or, the circumference of the compressed air is just in the reverse proportion with the pressing weight. its expansion.

From this property of the air, the invention of air-guns, air-pumps, and several artificial water-engines and works derive their origin.

§ 196. The more quantity of air is forced into a certain compass, the more increases its expansion or elasticity towards all sides; that is, the greater is its elastic power. Heat produces the same effect when applied to air; whereas with the cold it is the reverse, as therewith its elastic power is rendered less. When air comes into that degree of heat in which water boils it expands exactly

Of air one-third of its circumference; and this degree of elasticity has been found to be to the weight of the atmosphere, as 10 to 33.

its elastic power The more the air has been compressed, the greater will be its elastic power, by a force of fire equal to that power. From this property of air, astonishing and often dreadful effects may arise in chymistry, partly from negligence, partly from ignorance. Such effects will happen not only in that case when no sufficient room is left to the air for expanding within the closed vessels exposed to the fire; but with a much greater and more sudden violence they will exert their effect, when in the same operation the solution of a solid body is to be performed; because then the air comprehended in that solid substance, is discharged, unites with the air already inclosed in the vessel, renders it more dense, and from hence produces a greater degree of elastic power, and consequently the more violent effects.

§ 197. If not most kinds of natural bodies themselves are actually contained in the air, it may be proved by experience, that at least some, and the greater part of their substance are actually lodged and kept suspended therein; only that they differ in quantity and property in the different parts of the globe.

§ 198. Those never ceasing variations observable in our thermometers, prove sufficiently the presence of fire in the air, as not only existing in all kinds of bodies, but even in the *vacuum*, and in this with all the same power and equal effect as in the air.

§ 199. It

§ 199. It is generally known that from animal bodies, from vegetables, from rivers, seas, and from the whole earth, daily immense quantities of water evaporate into the air, and that from thence they fall down again in dews, rains, and snow, to impregnate the earth and vegetables with moisture, to cause the rise of springs, and to supply those as well as rivers and seas with water: yet that in every particle of air, at every time and place, water is actually contained, though in more or less quantity, appears from that Air contains water

1. At all times, and at all places, when by the air-pump the air is drawn out of the campana, the inside of the glass is covered with a moisture.
2. Because a perfectly dry, sharp and highly calcined fixed alcaline salt, does at all times, and at all places, attract moisture from the air, and becomes liquid.

§ 200. A volatile body, when it dissipates and rises up in the air, may carry off a certain part of a heavy solid body, united with the former. Since therefore all that immense number of volatile substances, which continually, from the whole surface of this globe, rise up in the air, are all united with earthy or some solid terrestreous particles, before they fly off, it is apparent that a considerable part of earth is carried up with them into the air, that it partly remains there, and according to circumstances falls down again, either by itself, or united with other substances. Of this the *soot* presents a plain instance; because when sublimed in a closed vessel, it leaves a considerable and earthy particles

Air quantity of earth behind. As then soot is nothing else but a collected smoke of combustible, vegetable matter, &c. and of this immense quantities are daily raised up into the air, and even remain there, the existence of earth in the air is rendered beyond all doubt. Without mentioning many other events of the same kind, such as the dust and sand from great wildernesses, the ashes of volcanos, &c. which are frequently known to be carried away to the distance of a hundred miles.

contains vegetable, § 201. All *odoriferous vegetables* emit these their essential spirits or vapours into the air, where they collect in so great a quantity, that often mariners and travellers by sea, have by the fragrant smell in the open sea, discovered the vicinity of land long before it could reach the eye. An amazing quantity of *vineous spirits* are continually generated by fermentation all over the surface of the earh, a substance almost unalterable in its property, which, as such, rises by itself and by its own nature up into the air. All kind of *vegetable oils* exhale by degrees entirely up in the air merely by the natural heat of the climate, and constitute there a phlogiston in this element; excepting only those few which are kept up in closed vessels, or in a very compact wood. All *natural acids*, *bitter* and *alcaline salts* of vegetables evaporate at last in the air, when they in length of time are freed of that fixed earth in which they were retained; their separation may be brought about either by fermentation and putrefaction, or by incineration and chrystallization. It has evern been observed, that entire particles of vegetables, in some kind of seeds, have been taken up by air, and carried away to immense

Margin notes: spirituous, (beside "tity of vineous spirits"); oily, (beside "the air. All kind"); saline, (beside "compact wood"); particles. (beside "when they in length").

immenſe diſtances: from which event, among other errors of that kind, thoſe of ſulphureous rains, bloody and the like waters, have taken riſe.

Air is full of animal particles, and the ſeed of inſects.

§ 202. From *animals*, ſo immenſe a quantity of particles are continually evaporated into the air, that nearly their whole ſubſtance is lodged in that element, and but a very ſmall part thereof left behind. This is daily proved by very common experience, as, from dead carcaſes expoſed to the air; from contagious diſtempers, when the air is ſaid to be infected; from the ſenſe of ſmell by animals, whereby they know to diſtinguiſh the difference of their ſpecies.

Urine and *dung* of animals require but a ſhort time of being conſumed and evaporated into the air. All animals, when dead, are for the moſt part carried off in the air by putrefaction; which happens equally when buried in the ground, only then in different intervals of time. How immenſely great is therefore that quantity of *animal ſubſtances*, which is perpetually communicated to, and united with the air; where they remain as in their proper element, and conſtitute, perhaps, ſome material ingredient to the conſervation and generation of the animal ſpecies *. It is not againſt all probability, that even fertile eggs, or the ſeed of certain animals, are contained in the regions of air, when experience proves what an immenſe number of inſects are brought down by ſome rains or winds, which cover the ſurface of the earth, and often deſtroy the fruits thereof.

* A curious and peculiar obſervation.

§ 203. Al-

Air contains even fossil bodies, sulphur, nitre, acids of sulphur, of nitre, of common salt, even fixed salts

§ 203. Altho' it might seem new and improbable, that even such solid substances as *fossil bodies* should rise up and lodge in the air, yet we shall soon be convinced that this is a very plain and perfect truth. For, the *sulphur* is such a compact and fossil body without doubt: and what an amazing quantity of sulphureous substances are not consumed every day by fire. *Sulphur* is burnt up daily in the great smelting-houses, by the roasting and smelting of minerals, and all this is dispersed into the air, though in the minutest particles. (§. 49.) Not to mention that quantity of sulphur which is consumed with gunpowder, and other common use. The existence of *nitrous acids* in the air, appears partly by its detonation with gunpowder, partly by the very generation of nitre in our atmosphere, neither of which could happen without air, and consequently these nitrous particles must needs be contained in the air. Further, when considered that these two acids, the *sulphureous* and *nitrous*, being actually contained in the air, are both of a stronger kind than the acid of common salt, and that continually such immense quantities of common salt are exposed to the air, it is plain that a great quantity of this *saline acid* must thereby be freed from its fixed earth by the two former stronger acids, and thence carried off into the air. To this comes further, that the *fixed salts* may, by an often repeated gentle solution, slow heat, evaporation, and inspissation, be entirely destroyed and rendered so volatile, as to fly off into the air by themselves. As commonly and surely then as this effect is obtained by artificial preparations, so does nature work the same process likewise, and perhaps in many other various ways. The existence

of

of *mercury* in the air, is daily experienced by miners with the loss of their health, in those mines where ores are worked by amalgamating mills. All *metals* and *semi-metals*, gold and silver excepted, are partly destroyed in the fire, and their volatile and unfixed particles driven up into the air, the fewer parts of it remaining but behind in a fixed state. *Metals* being dissolved in acids, some parts thereof go off with the acid in vapours: and since it appears by the above principles, that all kinds of acids are contained in the air, it is unquestionable that metals may be dissolved by air alone, and thence carried off with the air; an experiment daily proved and rendered beyond doubt. To this comes farther those certain mineral exhalations, known by the name of *mineral-damps*, in German, schwaden, above as well as underground, and the short life of miners exposed to these vapours; all which gives us undoubted instances that the mineral and subterranean bodies are no less raised up into the air, than other vapours. Air contains metals

§ 204. From these enumerated properties of air, the several effects thereof may now much readier be understood and explained. Effects of air

Some of these properties may be the following.

1. Air fills up every space round the whole earth, if not obstructed by another body. And since all kind of bodies are generated within this great space of the globe, all which is penetrated with air, it follows that some particles of air must unite with these bodies, and consequently none of them can be said to be without air.

2. As

2. As the weight and the warmth of air changes continually; and as either by cold or by heat the air is now expanded, then contracted, and as besides this some terrestreous particles ascend continually up in the air, it follows, that the air must be in a perpetual motion.
3. Further; besides heat, the pressure and motion of the external air as well as the elasticity of air contained in other bodies, makes, that no body whatsoever can be in a perfect state of rest, that is, without some degree of motion.
4. Since so many particles of almost every kind of bodies are actually contained in the air, and as they are therein in a continual motion, they can unite and mix themselves with the air in various ways and manners, and produce by that means those sudden and astonishing effects therein.
5. And as not every part of the globe produces the same kind of bodies, nor the same quantity of each, the bodies within the airy region must likewise differ in their kind and quantity, consequently the phenomenons of air cannot be the same every where alike.
6. Moreover since the various bodies contained in the air, unite themselves again either with these upon the surface of the earth, or with the air itself according to circumstances, the effects deriving therefrom, at No. 5, cannot be the same at every place.

CHAP.

CHAP. III.

OF WATER.

§ 205. WATER is not only contained in most bodies which are made use of in chymistry, but several chymical operations must entirely be performed with water. It is therefore needful to be acquainted with the chief properties of this element. Its definition is given to be a very fluid, transparent body, of no smell, taste, nor colour, and when in a certain degree of cold, turning into a hard, brittle, transparent substance, called *ice*. Whence some will give it merely the name of *ice* made fluid by heat.* Water Ice

§ 206. Whenever the heat of our atmosphere diminishes to a certain and always determined degree, the water congeals and turns into ice. The fluidity of water has therefore its cause

* This opinion seems to receive its probability from hence, that the first chaos may be considered as a substance without heat, so as to constitute a mixture of earthy and watery particles not only intermixed but congealed together without order. For then when heat was made and entered this congealed icy chaos, it may be imagined to have then melted away and separated itself naturally from the solid parts, leaving those as the earth and hills by themselves behind, and taking its place in the seas and rivers, according to its own gravity and fluidity.

from

Water from heat, so that merely by that its particles are kept separate and rendered fluid. This fluidity is so great, that by a small heat and very little motion it dissipates and disperses in the minutest atoms into the air; when by exact experiments it has been discovered what a quantity of water will evaporate in a certain degree of heat, in a certain time, and from a certain surface not exposed to the open air. It has likewise been observed, that clean pure water evaporates sooner than salt-water. For this reason, springs, rivers, and sweet seas, loose more water by evaporation, than the open sea. Evaporation is much helped by wind.

§ 207. It may easily appear that the particles of water must be very minute; but no method or certain rules have as yet been discovered by which they may be measured, nor may any thing with certainty be said with respect to their proportion with other bodies. For, although some will conclude of the particles of water being smaller than those of air, from that they can make way through some substances, which the air does not readily penetrate, such as leather, and some kinds of wood; yet this event does not clear the matter of doubt, since it is probable that these effects may arise from other causes not yet sufficiently examined. There are however many bodies through which water may not penetrate, such as some sorts of hard wood, most kind of stones, glass, hard burnt clay, and metal; and such as it cannot penetrate when cold, it can neither when warm or hot; only with some bodies it has been observed of penetrating them sooner when cold, than hot, which may have its reason from that

that the hot water takes a greater circumference than the cold. Water

§ 208. *Water* being rendered volatile by fire, it follows that water can never be in a perfect state of rest, though its motion may not be perceptible to the naked eye. Yet this motion may be discovered by the help of microscopes, so as likewise by the solution of salts in water, since this action cannot be done without motion even if it should be ascribed to an attractive power.* always in motion

§ 209. The particles of *water* are so homogeneous that hitherto no difference has been discovered in their composition. Their size, compactness, weight, and other properties remaining always the same unalterable. They admit of no compression like the air, and are consequently very solid consistent bodies; neither are they pliable, nor of a spiral form, as *Décartes* and *Stair* have given out.

§ 210. *Water* is seldom or never quite pure. For, as the air is always playing, not only upon its surface, but penetrating its whole bulk, and as every kind of volatile bodies are mixed and united with air, it necessarily follows that thereby the water must suffer a considerable change by the admixture of so many other bodies and ingredients, which proves itself by every experience very evi- seldom pure

* Which is often no more than an expression without meaning and a shelter of ignorance. For, whenever the true cause of a phenomenon cannot be explained or understood, it goes by the name of attraction.

dently

Water, dently. By these accidental causes as well as by the heat and cold, it further appears, that its weight, and so indeed its other properties must be greatly altered at different places and times. When therefore the specific weight of other bodies shall be examined by the hydrostatic balance, a careful regard should be had as to the weight and purity of water. Foul water may be rendered pure by distilling it in an equal degree of heat.

§ 211. *Water* has that peculiar property of uniting with other bodies, and to constitute therewith so perfect a mixture, that each the minutest particle may contain an equally proportionable part of the body it has dissolved This property of water is called its *dissolving power*. Yet it must be observed that sometimes this effect is partly owing to the body itself which has been dissolved therein.

its

§ 212. All kind of salts (See chap. 4. divis. 1.) will dissolve in water, either acids or alcaline, single or composed, fixed or volatile, whether they belong to the fossil, animal or vegetable kingdom.

dissolving

§ 213. This solution differs however with respect to the quantity of water employed as well as the heat required in the solution; and this difference arises partly from the quality of water, partly from that of the salts which are to be dissolved.

power.

§ 214. The more the water is in a state of rest the slower will the solution succeed, and the less

less quantity of salt it will dissolve; in contrary the more it is in motion the sooner and the more it dissolves. Again and consequently, the colder the water the slower is the solution, and the hotter it is, the sooner and more it will dissolve. When therefore as much salt has been dissolved in a boiling water as possibly it can dissolve, a proportionable quantity of the salt will then be dismissed and fall to the bottom, the cooler the water grows, so that at last when frozen to ice, the salt will separate almost entirely from the water, and remain nearly in a dry state, adhering to every part of the ice. From hence depends the principle of chrystallising, or making the common salt, which after the superfluous water is evaporated, falls to the bottom and collects at the sides of the vessel when cold. It is remarkable that this ice, to which the salt has collected, will dissolve in a much lesser degree of heat than other ice of pure water: the same effect happens when salt is thrown upon any ice of a pure water. Hence it is that sea, and every salt-water requires a much greater degree of cold before it freezes to ice, than sweet waters of springs to rivers. Water

§ 215. *Salt* in a fluid state, that is, such as is partly dissolved already in water, dissolves in any proportion of water added in more or less quantity. And here it must be observed that all those sorts which are called single salts, or acid spirits, are never quite without water, and consequently always in a state of solution: hence, if to any quantity of these acids, or likewise to each of the other composed salts, being like these brought into a state of solution, any quantity of water is added with salts.

it

if ever ſo ſmall, each particle of that water will always contain a proportionable and equal quantity of ſalt. The ſame proportion proceeds when more water is added to the ſame mixture, ſo that as yet it has not been obſerved how far the limits of this ſolution will extend.

§ 216. But when ſalts are in a dry ſtate, that is, without any moiſture of water, then each requires a certain time and a certain quantity of water to its ſolution. So will common ſalt require leſs time and leſs water than alum to its ſolution. According to Boerhaave's experiments, the ſalts require (in the thirty-eighth degree of heat by Fahrenheit's thermometer) the following proportion of water to their ſolution, viz.

Of common ſalt	4 parts require	13 parts of water.
Salt-petre	3	19
Iron-vitriol	1	16
Alum	1	14
Salt-armoniac	4	13
Borax	1	20
Engl. bitter-ſalt	4	5
Epſom ſalt	—	—
Salt of tartar	2	3

§ 217. Another very peculiar property of water is obſerved by the diſſolving of ſalts, which is, when the water has been ſo much ſaturated with one ſort of ſalt, that upon adding any more, it leaves the ſame undiſſolved at the bottom, this ſaturated water will however diſſolve a conſiderable quantity

quantity of another kind of ſalt, without diſmiſſing any of the firſt. Properties of water

§ 218. Again, water diſſolves the ſpirit of wine, though not by itſelf, but by the aſſiſtance of motion, with ſhaking both together in the veſſel. Since then the ſpirit of wine is nothing elſe but the pureſt oil of vegetables, having obtained this inflammable quality of a ſpirit by fermentation, it appears from hence that even the pureſt oils, when before properly changed, will perfectly diſſolve in water; which however ſucceeds the ſooner and readier, when before already diſſolved with a ſmall portion of water. Hence it is that common brandy diſſolves much readier in water, than the ſpirit of wine.* But if water has been ſaturated with ſalt, then it will no more unite with the ſpirit of wine, though ever ſo much motion is given with ſtirring and ſhaking the mixture. Yet there are ſome ſorts of ſalt, which, being of ſuch a nature as to part eaſily from the water, do not prevent its uniting with the ſpirit of wine, but give up their place to the ſpirit and fall to the bottom in a ſolid form.

A diſtilled oil being united with ſpirit of wine, and then pouring it in water, the ſpirit will ſtill unite with the water, and leave the oil by itſelf again ſwimming on the ſurface. Hence it follows that ſpirit of wine, having but the leaſt admixture of water, cannot diſſolve theſe oils and unites therefore much readier with water than with oil; and that theſe oils remain ſtill oil, though diſſolved in With oils

* **Becauſe brandy contains already a good deal of water.**

H the

Properties of water the spirit, and though they seem to have the same form and appearance with the spirit.

with resins. All resins being dissolved in spirit of wine, render the water added to the solution, milk-white, and recover therein their first form.

with soap. § 219. All *soap*, being a mixture of oil and of alcaline-salt, dissolves in water, it may either be made by art, or produced by nature, either of a fixed or of a volatile kind. And it is by means of *soap* that all sorts of oil and resin are soluble in water, which, without this intermedium can hardly be done. For, when an essential oil shall be united with spirit of wine, it must be kept a long time with the spirit in a gentle heat and repeatedly distilled over, and then only that part of the oil which therewith has been highly subtilised, unites with the spirit of wine, which being obtained, they both readily unite with the water.

§ 220. That the air may be dissolved by water, so that each particle of water may contain an equal part of air in proportion to the whole quantity. *See the chapt. on air.*

§ 221. All *calcareous*, so as other substances of the fossil as well as animal kingdom, having first been dissolved in their own proper dissolvent menstrua, will then in the same manner dissolve in water, as the salts do when in a state of solution. It is likewise said that almost all kind of bodies, even metals, may be dissolved merely by water, by a long and continual trituration: but the question is, if this effect is produced by water only, or rather

rather by the acids of the air, which may introduce themselves into the water by that continual motion, and change of its surface, made by trituration. Properties of water

§ 222. It has been represented in the foregoing, how water will dissolve most kind of bodies; it remains now to shew that, like the fire, water has likewise the reverse quality, that is, to compose and consolidate bodies. It is certain that neither in the animal nor in the vegetable kingdom any thing can generate or grow without water, it may be considered as constituting a real and substantial part of animals and vegetables, or only as a medium or vehicle by which the growing and nourishing parts are conveyed to these bodies: whence every particle is found containing some portion of water, even the oils and vineous spirits not excepted. But how far water may constitute a necessary ingredient even to the generation of hard and solid fossil bodies, may not be so easily conceived, since our senses are not permitted to look into that secret operation of nature. However we know by experience that stones are in the beginning a soft substance, and that they contain water, for when taken in their present state of hardness, some part of water is obtained from stones by the application of fire. As for metals, the presence of water appears at least of making a requisite to their generation, if it constitutes not even a part of their substance. For in sulphur, we find a great quantity of water contained, and sulphur is known to make an essential part of most kind of ores. We know likewise by experience that not only ores, but even solid metals have collected in mines and first consolidated in a vapourous form, which

Of water form they could not have obtained without aquatic particles. By art we learn likewise how fossil bodies may be converted into hard substances by the sole admixture of water, so as to remain partly united and fixed with them. Plaster, moistened with water, grows instantly a hard substance. No kind of argillaceous earth could be burnt to hardness in the fire, when in a perfectly dry form of a powder, but must first be mixed with water. So neither could lime and sand be made up into a solid substance, without being first united with water. Not to mention that no loam nor cement may be made without water or fluid matter.

§ 223. *Water* produces in two peculiar circumstances, very great and powerful effects,

1. When by heat it is driven up into a steam, as we see in the papinian-engine, and those forcing pumps used for extinguishing the fire, and others for raising water from great depths.

2. When frozen to ice; for then nothing can resist its power of expansion.*

§ 224. Of *cold*, how it may be produced by art in and with water, we will only mention in general that the common method is, by mixing snow or ice with common salt. If a single salt is taken, the cold will be the greater and quicker, and the stronger this salt is, the greater will be the degree of cold.

* Yet it may be proved that in the first case this effect may be attributed to the air, being rarified by heat, and in the second the effect proceeds merely from an expansion of air and some degree of heat contained therein.

CHAP.

C H A P. IV.

OF EARTH.

§ 225. ALTHOUGH *earth* may not appear a great ingredient in chymiſtry, yet this chapter will ſhew that, according to its definition (§ 165.) it may with great propriety be reckoned to the *chymical agents*. *Earth* is ſaid to be a foſſil, ſimple, hard, fixed, friable body, not fluxing in the fire, and neither ſoluble in air nor water, nor ſpirits of wine, nor in any oil. Earth

But we underſtand by earth, a pure unmixed earth, none of thoſe boles, medical earths, and the like earthy ſubſtances, which are a compound of fattiſh, ſometimes vitriolic, aluminous, nitrous, and many other foreign matters, from which thoſe earths receive their aſcribed virtue and effect. But when they have been properly cleanſed by fire, or water, they may then come pretty near to a pure earth. Much leſs may ſuch kinds of earth, which are found on the ſurface of the globe, be reckoned for a pure earth, becauſe theſe are a compound of very various mixtures, ſuch as of fire, air, water, ſalts, oils, foſſil, animal, and vegetable particles, and of but a ſmall portion of pure earth.

Pure earth or

§ 226. This pure earth is no less than most other bodies, contained likewise in the air, from whence it may be obtained in the following manner;

virgin earth, how obtained from air.

Let a clean rain-water be gently distilled, and there will be found some solid substance remaining in the retort: This remainder being dryed and burnt, some ashes are obtained; those being elixivated with clean water, a clear, fine, white earth remains, and this is called *virgin-earth*. How this earth came to be in the air has partly been shewn in the second chapter. And how this earth, which was before suspended in the air, can now represent a prefectly fixed substance which suffers no alteration in the strongest fire, will no more be a matter of surprise, when considered that heavy, fixed, solid bodies may be carried off by the motion of a fluid one, and by those volatile particles with which those fixed bodies were united, of which the soot has given us a clear instance.

from vegetables,

§ 227. This *virgin earth* may be obtained from every kind of vegetables, so as likewise from soot, in the following manner:

1. By separating their parts by distillation.

2. By incineration in the open air.

In the first manner, the wood, plant, or the soot, is put in a glass retort, and the volatile parts distilled over by degrees, which consist of water, of a spirit, of acid, and alcaline salts, and of various oils. In the retort remains a black coal. This must

must be put in a clean iron pan, and burnt to ashes, which, when washed and elixivated with clean water, leaves the same fine earth as above shewn. If the volatile substances obtained from it, are distilled again, another such black coal remains behind, of which the same fine earth may be obtained by proceding as before. Virgin earth.

The oils which have been obtained by that distillation, leave as many times the like black coal behind, as they are repeatedly distilled, yet without containing any salt, so that it requires only calcining, whence it appears that most part of that oil may by a repeated distillation be reduced into such earth.* However, by the same repeated distillations the oil becomes at last as light, penetrating, and subtle, as a spirit of wine; but great part of its quantity, as likewise of its essential spirit, from whence it had its flavour and taste, will then be lost.

After the second manner, the soot or plant is only burnt to ashes in an open fire, then cleaned of its salt and sand by washing and elixivating, and therewith this fine earth is obtained at once with less trouble indeed, but likewise in a far less quantity; because great part is carried off by the volatile particles which rise up in a thick smoke during the burning.

§ 228. In these operations, an alcaline fixed salt is obtained by the elixivation, which, though it had been cleansed by the filtration of the lye from all earthy substances, so that by the best microscopes

* This deserves to be well noticed.

Virgin earth

copes no ſigns of earth could be diſcovered therein; yet a conſiderable part of the ſame fine earth may be obtained from this alcaline lye in the following manner: The liquor having firſt been rendered perfectly clear and pure by a careful filtration, let it gently evaporate in a flat glaſs veſſel, to the conſiſtence of honey, then put the matter in a clean iron pan over the fire, till it is reduced into a dry ſalt; during which operation it muſt be continually ſtirred. Put this ſalt in a crucible and a cover upon it, and let it melt in a ſtrong fire. When in perfect fuſion pour it out in a clean warmed mortar of braſs, and grind it with a piſton made likewiſe warm, to a powder; put this powder in a flat glaſs veſſel, and ſet it in a cool place where no duſt may fall into it, and it will ſoon run in a liquor and leave a fine white powder at the bottom. This powder when edulcorated from its ſaline admixture, is now that ſame fine *virgin-earth*. The ſame proceſs being repeated ſeveral times, moſt part of this ſalt may be converted into the ſame earth. It is obſervable, that this ſalt may not be obtained from vegetables, unleſs the incineration is performed in the open air. For, when a plant is burnt in a cloſe veſſel, though ever ſo ſtrong a fire is given, it will indeed leave the ſame black coal, but no fixed alcaline ſalt may be obtained of it, till this coal is expoſed again to a fire in the open air.

From hence we learn,

1. That no fixed alcaline ſalt is contained in vegetables from the beginning by themſelves, but that it is generated therein during the incineration, when in that operation, the phlo-

giſtic-

giſtic-oils are expelled, and the pure earth united with the ſalt by the action of fire. Virgin earth

2. That this ſalt receives its fixity from that earth with which it is united, being retained and kept up by this earth juſt in the ſame manner as the oils and ſpirits of vegetables are more or leſs fixed, in proportion as they contain more or leſs earth. (See § 228.)

§ 229. This *virgin earth* may further be ſeparated from vegetables by *putrefaction*. For, by the intimate motion thereof, this earth is ſeparated from the oily and ſaline ſubſtances. If therefore theſe vegetables are burnt in the fire after their putrefaction, then only a volatile ſalt is obtained, without any of the fixed; though before the putrefaction they would have yielded a great quantity of fixed alcali by this incineration. However, that motion which obtains only by fermentation, is not altogether ſufficient to ſeparate the earth entirely from its ſalt and oil, though part of that oil is changed therewith into a vineous ſpirit: therefore a fixed alcaline ſalt may ſtill be obtained from them after they have fermented, as appears from the calcined tartar.*

§ 230. From *animals* the ſame *virgin-earth*, exactly equal to that from *vegetables*, may be obtained in three different ways, viz. from animals

1. By ſeparating their parts in cloſed veſſels.
2. By burning them in open fire.
3. By putrefaction.

* Here, it ſeems, the author explains himſelf not quite clear enough.

However,

Virgin earth However the following difference is here to be observed, viz.

a. That no fixed alcaline salt may be obtained from the ashes of animal substances, so as it is in vegetables; but that animal substances produce always a volatile alcaline salt; which salt, without a previous putrefaction, is found but in a very few sorts of vegetables, such as *cochlearia* and *mustard-seed.*

b. That animals do never produce salts of so sharp and acidous a nature as vegetables.

With regard to the volatility of these salts, it may be observed, that since the fixity of salts has its cause and origin from that earth which they are united with, the difference of the fixity of salts between the vegetable and animal substances may probably arise from this—that the earth in animals is not so copiously nor so intimately united with their oils and salts as it is in vegetables.

§ 231. It will be useful to give a more particular description of the first method by which this virgin earth is to be separated (in closed vessels) from animal substances; as it furnishes at once both a chymical instruction, and a knowledge of the constituent parts of animal bodies. It is as follows:

from animals Take of any animal substance in a liquid form, either blood, urine, &c. in a clean well closed retort; let the heat begin from the lowest degree gradually to the highest. In the 212th degree of Farenheit's thermometer, a great quantity of water will distill over, in the same manner as it happens with vegetables

tables in that degree: this water will make itself known by a subtle smell, and a very disagreeable taste, but no earth will as yet be observed therein. The fire being increased, a light yellow stinking matter, commonly called spirit, rises over in the receiver, which is so alcaline as to effervesce with the acids. This matter or spirit being put in another retort, and distilled over, there remains some substance at the bottom in the retort, which, when calcined, gives some of the pure fixed virgin earth. But if to that which has remained in the retort, and of which that spirit has been distilled off, a stronger fire is given, a great quantity of animal oil rises over; which, for the most part, may be reduced into the same virgin-earth, by observing the same method as we have shewn with the vegetable oils, (See § 228.) when these oils will likewise be rendered therewith purer and more volatile. With this oil, as well as after it, comes the volatile salt of animals over, which at first is much replete with the oil, and pretty fast united with it; by which its great volatility is in some measure bound up, so as to retain some fixity. For, so soon as this oil is separated, the salt becomes very volatile, and leaves by repeated distillation no earth, but only some water behind at each time. Those oils being driven out, and the fire very much increased, a very black, thick, tough and heavy oil rises over, which by frequent distillations, becomes at each time clearer and more subtle and volatile, leaving always a good part of earth behind. If after these last oils are risen over, the fire is still given in a greater degree to the black remaining substance in the retort, it pushes at last out thick, blue lightening damps, Virgin earth

which

Virgin earth which, in the water contained in the receiver, condense, fall to the bottom, and constitute a phosphorus. But from the black substance which remains behind in the retort, a pure white earth is obtained, when calcined in an open vessel.

in salts § 232. In the *fossil*, or *mineral kingdom*, this *virgin earth* is chiefly found in salts, such as saltpetre, rock-salt, sea-salt, and spring-salt, by dissolving them in the purest water, and keeping them for a long time in a gentle heat in that state of solution: for, then an earth will fall by itself to the bottom, which may no more be dissolved in water. This being separated from the liquor, the lye must be evaporated 'till a pellicle appears on the surface, then brought in a cold place where the salt will form itself in such figures as are proper to each species. The remainder of the lye being again evaporated, and set to crystallise, other crystals will shoot, but not so perfect as those of the first shooting. The same operation being repeated with the remaining lye, 'till at last no more crystals will shoot, a thick, sharp, saline liquor remains, which can hardly be brought to dryness; and if at last, by a long-continued heat it is made dry, gives some of the virgin-earth, but apt to liquify again, whenever exposed to the open air. But at each of the foregoing operations some part of that earth is found settling at the bottom. By a repeated solution, a crystallisation of these *fossil salts*, they become at last volatile, fly off entirely into the air, and leave nothing behind but some earth.

§ 233. From

§ 233. From the ſame *mineral ſalts* this *pure earth* may likewiſe be obtained by *diſtillation*, in the following manner: Grind them to a powder, mix them with thrice as much clay, bolus, brick-duſt, or pure earth, being perfectly dry: put the mixture in a retort with a receiver applied to it, give ſucceſſively a very ſtrong fire, and the ſalt will diſtill over in an acid, fluid, volatile, cauſtic ſubſtance, leaving its earth behind with a few of ſaline particles in the ſame earth, which it had been mixed with, which muſt be elixivated, cryſtalliſed, and reduced as before. Theſe cauſtic ſalts being diſtilled the ſecond time, there remains a yellow ſubſtance behind, out of which a portion of this virgin earth is obtained. But the oftener theſe ſalts are deprived of that earth, the more they grow volatile, ſo that at laſt they fly off by themſelves in the air like a ſubtle vapour. It appears, therefore, that even theſe mineral ſalts receive their fixity from that earth they are united with. Virgin earth

But here it may be obſerved, as a peculiar circumſtance:

1. That a pure vitriolic acid, remains ſtill fixed in the fire as far as to the 560th degree of Farenheit's thermometer, although entirely diveſted of its earth.

2. That the moſt volatile acid ſalts, when united with the moſt volatile kind of alcaline ſalts, conſtitute a ſemi-fixed ſalt-armoniac.

By

Virgin earth

After the same method as has been given above, *alum* may be reduced into a large quantity of an argillaceous earth, besides a portion of volatile salt. *Vitriol* may, by a frequent solution in water, gentle heat, and repeated crystallisation, for the most part be reduced into a yellow ocher; to which, however, the name of a pure earth is as yet disputed. In the same time a thick, fat, acrid, volatile substance is obtained, the rest flies off in the air.

from

§ 234. All *sulphureous substances* of the fossil kind, such as Jews-pitch, rock-bitumen, petreolum, rock-balsam, (naphta) emit a black smoke and copious soot when burnt, and leave some earth behind, which being further calcined, becomes likewise a pure earth.

sulphur.

At the first sublimation of sulphur in a closed vessel, by making the flowers of sulphur, some of this earth is obtained. The existence of earth in the sulphur may be judged of from its generation, as it is known to be made up of a mineral oil and a vitriolic acid, both of which contain much earth, as we have seen, § 228.

§ 235. The art of decomposing *metals* into their constituent parts, is so difficult that little can be said thereof with certainty, and consequently nothing with respect to their earth.—For, though metals may be reduced into a fine powder of no taste, yet this powder is always reducible to its first metalline form, by the addition of a phlogiston: which is not the case with pure

virgin

virgin earth. So with a slow heat, the same earth-like appearance may be given to mercury; but it will soon turn again into a current mercury when afterwards a stronger fire is given to that substance. Therefore *no* real *virgin-earth* has been as yet produced *from metals*. On the contrary, that ancient opinion of former chymists seems to receive a tolerable probability, that *metals consist* mostly of *a mercury fixed by some other body.* Virgin earth

§ 236. From this chapter it appears, that this *virgin earth* constitutes a principal ingredient in the composition of all vegetables and animals, as well as of some fossils or mineral bodies; that it causes their cohesion, that it fixes the volatile parts of these bodies, renders them solid, either wholly or in part, and thereby prevents the connexion of their parts from being disunited and destroyed, either by their own fluids, or by the air, or by water, or by fire.

§ 237. Most kind of those vessels in which chymical operations are performed, are composed of this kind of earth; they may be of glass, clay, or china. This earth when mixed in a right proportion with pure fixed salts, keeps them asunder and from fluxing in a strong fire, whence it is that so the fire can separate and carry off the volatile from the fixed parts of the salt. Thus tartar, salt-petre, and common salt will melt in a strong fire, and remain fixed for a long time; but when tartar is mixed with thrice as much pure earth, for example, with calcined bones, most part of it becomes volatile, and soon flies off in the same degree of fire. In the Its use

Virgin earth. the same manner, the acid spirits may be separated from salt-petre and common salt. To purify the volatile salts of animals and vegetables from their oils, with which they adhere sometimes very tenaciously, the best way is again to mix them with such pure earth, and to sublime them in a high vessel with a sudden heat, because this earth swallows the oil up, and retains it from rising up with the salt. When tough glutinous bodies, such as its honey, wax, &c. are to be decomposed by way of distillation, they will foam up, rise into the neck of the retort, and run over; the same thing happens with those substances which remain behind by the distilling of eggs, blood, and urine; by which then not only the intended separation is frustrated, but often great danger and mischief caused, when the neck of the retort being stuffed up, and the elastic power of air increased by heat, various it will make the vessel fly in pieces. For that purpose these substances are mixed with this earth, in order to keep them from foaming up, and to make them bear a sufficient heat, such as required to their separation.

uses In the operation of *separating* the *perfect* from other *metals* with lead, this pure earth is of great utility; not only in the art of assaying, but in smelting ores and metals. In the first, *coppels* are made of this earth; in the other, the *great tests*, and in silver-burning, the *clay tests*. For, since this earth endures the strongest heat without vitrifying; and yet, when before wetted and compressed in a mould, keeps so fast together, that metals in their

their metalline form cannot penetrate it; which however, they would readily do, if the earth did vitrify: and further, since the lead, together with its imperfect metals, goes partly off in fumes, partly vitrifies in a great heat, but gold and silver remain indestructible, all the metallic compound contained in the lead, as soon as vitrified, soaks through this earth, vanishes, and leaves the gold and silver pure together in one lump by itself on the surface. Theory of testing.

The same operation upon the test being made in the great way, only this difference is to be observed: that here most part of the vitrified lead, which then is called *lytharge*, is let out through a passage called the *lytharge-channel*; which is done partly to forward the operation, partly to keep the lytharge as a commodity for sale. The silver remaining after this operation upon the test, is further brought upon a smaller test, called the *clay-test*, where by a flaming fire, directed in a particular manner to play upon its surface by means of good bellows, it is melted again by itself, and therewith refined from the remaining particles of lead and other impure metals; which, as a separate operation, is called the *silver-burning*. Lytharge. Silver-burning.

CHAP. V.

OF DISSOLVENT MENSTRUA.

Theory § 238. A BODY which decomposes another body, absorbs and retains it in such a manner that neither of both may be further discerned, even by the help of microscopes, in a separated state, is called a *dissolvent menstruum*.

of solution. § 239. Since all chymical operations depend upon the *division* and *composition* of bodies, but the *dividing* of one body from another must be performed with *dissolvent-menstrua*, and the *composition* of bodies may not be obtained without being before *dissolved*; it follows, that the knowledge of *dissolvent-menstrua* is of great consequence in chymistry. Yet this *division* must be well distinguished from a mechanical division; this latter being done by the different gravity of bodies, or by other bodies which receive their motion from an external power: when, in contrary, the motion and the consequent *division* in chymical solutions, arises from the form and composition of the parts of the dissolvent body as well as of that which is to be dissolved; and from a power contained within each of them to unite themselves and to remain together

ther: though it cannot be denied that this power may be assisted by a mechanical motion and by heat. Dissolvent menstrua,

§ 240. These *dissolvent menstrua* are either *dry* or *liquid*. The *dry* are mercury, and all these which by means of fire perform the solution, being brought in fusion. The *liquid* are those which by the addition of water are rendered fluid. dry or liquid.

§ 241. These four genera of *stones* mentioned in chapter III. of the first division, among which we shall comprehend the *earths* specified in the second chapter, will neither of them alone melt in the strongest fire; but when either mixed with fixed alcaline salts, or they being themselves mixed together without any other addition, they will come in fusion, remain together, and constitute an uniform *glass*. For this reason they ought to be considered not only as real dissolvent menstrua by themselves, but deserve the more attention, as the principles of *glass-making*, of *assaying*, and of *smelting*, depend mostly thereupon.

§ 242. *Calcareous stones* (🜄) will dissolve the fixed alcaline salts, and vitrify therewith. They produce the same effect when only mixed with argillaceous stones, though none of them, when alone, may be brought in fusion with the strongest fire. But calcareous stones will not dissolve, that is to say, will neither flux nor vitrify with the gypseous nor with the vitrescent stones: except the white opake quarz, and the glass-spar, which when mixed with the calcareous stones do unite and flux together; Calcareous stones.

glass-spar more than the quarz. The more of the glass-spar is added, the more fusible and softer will be the glass or scoria. They shew likewise this difference with the calcareous stones, that the vitrification obtained with quarz makes a blueish glass with smalt; but that of the glass-spar a greenish one: which must be owing to a metalline nature. There has been observed a remarkable solution of those calcareous stones, and chiefly of chalk, which is, that when mixed with lytharge, or with glass of antimony, it will reduce both into its metallic form. This is the more particular, as it has always been believed that no metallic calx or scoria could be restored in its metallic form *without a phlogiston*. In smelting works of iron, the *calcareous-stones* are with advantage used for fluxing and refining that metal, wherefore they mix the iron-stone or ore usually with *lime-stone*, *marble*, or *marl-stones*.

Argillaceous stones.

§ 243. *Argillaceous stones* ( ) dissolve the fixed alcaline salt, but they require it in a greater quantity than the calcareous kind. When mixed with gypseous stones, they dissolve one another, and turn into a hard, semi-transparent, milky glass. They dissolve the fusible kind of vitrescent stones, such as glass-spar, &c. but with the refractory sorts they only bake together, and turn into a hard mixture, such as is seen with the common potters-ware.

§ 244. *Gypseous stones* ( ) dissolve the fixed alcaline salt, and among the vitrescent stones, only the glass-spar, with which they make a whitish opake glass.

§ 245. *Vi-*

§ 245. *Vitrescent stones* (▽—⊖) dissolve like the former three fossils, the fixed alcaline salt, but make much easier a fine transparent glass with it; whence the *common glass* is mostly made of this mixture, though the composition is sometimes variously changed with other ingredients; such as *magnese*, called by the Germans *brown-stone*; calcined bones, &c. So as a common dark glass is made at some places only from ashes, and even of slate. **Vitrescent stones. Common glass.**

Vitrescent stones, when mixed with as much borax, and melted with a proper fire, make a beautiful transparent glass, so hard as to strike fire; and which, with adding some more fixed alcaline salt, or salt petre, constitutes the principle of the *hard compositions*, or *artificial precious stones*: of which more in the practical part. **Pastes.**

§ 246. In general it is to be observed, that all those compounds of different stones will dissolve and flux much better with the addition of glass, of lytharge, or such as is subservient to those, viz. minium, borax, and fixed alcaline salts. Even such stones, of which two different sorts do not dissolve together, will then dissolve, when three sorts, of which at least one will dissolve the other, are brought together: and better, if of these three, two have been already dissolved before: so that one sort, which dissolves each of the two others alone, is like a mediator between them both. For example: *calcareous* and *gypseous-stone* do not dissolve together; but since *argillaceous-stones* and earths will dissolve the *calcareous* as well as the *gypseous-stones*, those two will be dissolved only with the addition of *argillaceous-stones*, and all three will dissolve and melt into a **General observations.**

glass. An instance which explains the first proposition may be this; neither *calcareous* nor *argillaceous stones* will dissolve the *refractory* sorts of *vitrescent-stones*; but since the *calcareous* and *argillaceous-stones* dissolve one another, these two, mixed with the said sort of *vitrescent-stones*, will dissolve it when brought together to melt.

In order to perceive, at one view, which stone kind will dissolve together, or not, and to understand the better how these mixtures, according to convenience and circumstances, may be made, the following TABLE will shew the reciprocal effects of each.

Table of solutions.

Argillaceous and *calcareous* stones dissolve one another, and vitrify together.

Argillaceous and *gypseous* stones dissolve one another, and vitrify together.

Argillaceous and *refractory vitrescent* stones do *not* dissolve one another.

Argillaceous and *fusible vitrescent* stones dissolve one another.

Gypseous and *calcareous* stones do *not* dissolve one another.

Gypseous and *refractory vitrescent* stones do *not* dissolve one another.

Gypseous and *fusible vitrescent* stones dissolve one another.

Calcareous and *refractory vitrescent* ſtones do *not* diſſolve one another.

Calcareous and *fuſible vitreſcent* ſtones do *not* diſſolve one another.

Nota. Among the *fuſible vitreſcent* ſtones, the *glaſs-ſpar* diſſolves beſt in the fire; and any mixture made therewith will afterwards eaſily unite, and bring other refractory ſorts in fuſion.

§ 247. *Fixed alcaline ſalt* (⊖▽) diſſolves water, inaſmuch as to attract it even out of the air. § 199. Fixed-alcali.

This ſalt will diſſolve ſpirit of wine when perfectly rectified; but if the leaſt water is among the ſpirit, the ſalt unites with the water, and expels the ſpirit. From hence the ſpirit of wine may inſtantly be rectified of its water, by throwing alcaline ſalt into it.

Diſtilled oils are diſſolved with the fixed alcaline ſalt when it is perfectly dry, and make a kind of ſoap; but both muſt be perfectly void of moiſture.

The *expreſſed oil of vegetables*, as well as the fat or oil of animals, ſuch as train-oil, &c. are eaſily diſſolved with alcaline ſalts by the addition of quicklime, water, and heat, as is the uſual compoſition of *common-ſoap*. The *fixed alcali* diſſolves all acid ſalts, and both unite much readier with themſelves than with water: therefore the water may be ſeparated from both in that manner. Theſe two ſalts, the al-

Fixed-alcaly alcaline and acid, when mixed, constitute a neuter salt. (*See the first division, chap.* 4, *of salts.*)

Here it may be observed.

1. That the alcaline salt unites better with a strong acid than with a weaker one.
2. Therefore when united before with a weak acid, it leaves that and unites with the stronger when applied to it.
3. That after this union, nearly the same salt arises again, of which the acid salt was made up.

acuated. When an alcaline lixivium is acuated with calcareous substances, it will then dissolve almost every vegetable and animal substance.

How this salt dissolves all earths and stones, and in the fire will turn them into glass, has been treated of in the 241, 242, 243, 244 paragraphs.

§ 248. *Fixed alcaline salt* alone does not dissolve gold, silver, and mercury, neither in the dry nor liquid way. For this reason and according to the preceeding §, these metals when united with an acid, may be freed of it with the fixed alcaline salt, and reduced to their metalline form without loss; when otherwise these acids, chiefly if driven out with fire, being united with these metals, would render them volatile, and carry off a great part of the metal. No other kind of dissolvent agents can perform this reduction with the same advantage,

advantage, except fat or grease. But when the alcaline salt is made and prepared in such a manner, as it is required for making the Prussian-blue, then it will dissolve gold, silver, mercury, zinc, and bismuth, in the liquid way; the gold more than the silver. Fixed-alcali.

§ 249. *Iron*, *copper*, *tin*, and *semi-metals*, when melted with *fixed alcaline salt*, without adding a phlogiston, are at last destroyed.

Sulphur, when melted in the fire, and a perfectly dry *fixed alcaline salt* added to it, they dissolve one another so intimately that this new compound dissolves not only in water, but liquifies even in the air.

Therefore metals united with sulphur, may be freed of it by means of this salt; and again, when metals are united with fixed alcaline salt, as for example, an alcaline copper-scoria, they may be freed of it with sulphur. Copper may be dissolved by degrees with *oil of tartar per deliquium*.

§ 250. The *volatile alcaline salt* (⊖A) dissolves gold, silver, mercury, copper, zinc, bismuth, and sulphur, but more the silver than gold. Otherwise it agrees in its solutions and effects with the fixed alcaline salt, except where the fixity is required, as in *glass making*. Volatile-alcali.

§ 251. The *acid salts of vegetables* (+) differ chiefly one from another with respect to their preparation from each plant, so as likewise in subtlety and purity. For they are either actually comprehended Acid, or salts of vegetables.

therein,

therein, as in lemons, and then easily to be obtained, or implicitly concealed in vegetables, and then to be made by fermentation, distillation, or incineration. But with respect to their dissolving quality, they agree mostly together and will dissolve most kind of vegetable and animal substances; as horn, bone, claws, shells, and all calcareous earths and stones; amongst the metals, and semi-metals, they dissolve copper, lead, and zinc, the easiest; but gold, silver, and mercury not at all. Therefore if mercury is adulterated with other metals, it may be cleansed with vinegar, by the assistance of tritaration. It is remarkable that not only these acid salts, but even metals will dissolve easier and sooner, when by themselves, than when united and mixed together. From hence depends the principle of etching with wood-vinegar, or with tartar and salt in the brass-works; and likewise the utility of brass pump-pipes in such mines where the waters are of a corrosive quality. From the same reason brass indures the air better than copper.

Acid of vitriol. § 252. The *acid of vitriol* (+⊖) (§ 30.) dissolves spirit of wine, oils, alcaline stones and earths, likewise iron, zinc, copper, bismuth, arsenic, cobalt, and silver, but the soonest iron and zinc; to which purpose it must be diluted with twenty to thirty parts of water, when during the solution it emits vapours of a garlic-like smell, which, with the iron, as well as with zinc, will instantly inflame by the approach of a lighted candle or coal, and when the vessel is of a narrow neck, communicate itself to the whole substance and make the glass fly in pieces with violence. But if this acid is applyed to silver and copper,

copper, it will not touch either of them, unless it be very much concentrated, and even then it requires a boiling heat to dissolve these metals. When afterwards water is added to the solution of copper, it changes its colour into blue. But the silver is precipitated by pouring water into the solution. Mercury, lead, tin, bismuth, antimony, and arsenic, are corroded and but a part of these metals dissolved by it, which unites with water, so as to pass with it thro' the filter; and here it is to be observed that arsenic will dissolve best when in its ore, such as pyrite, sandarac, (Roushgelb) orpiment, testaceous-cobalt. Gold is not at all affected by this acid.

§ 253. *Aquafortis*, (🜅) *or spirit of nitre*, (+ ⦶) dissolves spirit of wine, oils, calcareous (alcaline) earths and stones, iron, copper, lead, silver, mercury, regulus of antimony, bismuth, zinc, arsenic, and cobalt; tin but imperfectly, gold not at all, which consequently may be separated from other metals by aquafortis. And since this acid dissolves one species more readily than the other, a body which has been dissolved already in aquafortis, may be separated from it by the addition of such a one, which will sooner dissolve in this acid than the other; this is then called *precipitation*. Hence silver will precipitate by throwing copper in the solution, copper with adding iron, iron with zinc, zinc with adding an alcaline-earth, and the alcaline-earth will precipitate with alcaline salt. Aqua-fortis.

§ 254. *Spirit of common salt* (+ ⊖) dissolves tartar, oils, calcareous-earths and stones, and those two latter much better than the former acids; when iron is dissolved with this acid, the solution is of a yellow- Spirit of salt.

greenish

greenish colour, but the solution of copper is grass-green. Of tin, this acid dissolves a great quantity with violence and great noise. Of lead, it dissolves but a part, for after it has stood for some time, it deposits a white powder at the bottom. Of mercury it dissolves but some part, but of pure gold and silver, none at all. It does not dissolve regulus of antimony, unless very highly concentraited, but even then if but the smallest part of water, or but a moist air, enters the solution, it falls down again in a white powder. It dissolves zinc, bismuth, cobalt, and arsenic.

Aquaregia. § 255. *Spirit of common salt* when united with *spirit* of *nitre* in a due proportion, it is called *aquaregis*, (🜅) so named from being the only acid which dissolves the king of metals, gold. *Aquaregis* dissolves likewise spirit of wine, oils, all sorts of calcareous stones and earths, iron, copper, tin, mercury, regulus of antimony, bismuth, cobalt, and zinc perfectly, lead better than the spirit of common salt, though the solution turns a little foul, but silver is not at all affected by it if both acids are mixed in the right proportion, but if too little of the spirit of salt is put to that of nitre, then it will corrode the silver, and even dissolve some part of it. For this reason it is always the safest way to separate gold from silver with aquafortis rather than aquaregis, because gold is never affected by aquafortis whereas silver may partly be dissolved by aquaregis, in the case before mentioned, that is, when it is not made strong enough; and then as much silver as has been dissolved therewith remains with the gold-solution, and makes the separation incorrect: moreover the operation succeeds much sooner with aquafortis. But in case the separation

ſeparation ſhall be done to other purpoſes with *aquaregis*, it is better to add rather too much than too little of the ſpirit of ſalt to that of nitre. A very good aquaregis is inſtantly made by putting a fourth part (in weight) of ſalt armoniac into aquafortis, where it diſſolves and renders its colour yellow. Yet ſince the ſalt armoniac contains, beſides the acid of common ſalt, a volatile alcaline ſpirit, and the volatile alcaly even alone diſſolves gold, (§ 250.) it appears from hence that here the ſolution of gold ariſes not only from uniting the ſpirit of common ſalt with the nitreous acid, but from the volatile alcaline ſpirit itſelf, and conſequently that this is ſomething more than a ſingle aquaregis, which conſiſts only of the acid of common ſalt with that of nitre.

§ 256. *Salt armoniac* (⊖✱) being diſſolved in water, it will diſſolve gums, reſins, copper and iron-filings, upon being boiled therein. But if with this ſalt, in its dry form, ſulphur, and ſulphureous ſubſtances, likewiſe metals and ſemi-metals, are mixed and well ground, and put together in a cloſed veſſel, and then a proper fire is given to theſe mixtures, this ſalt diſſolves them, opens and rarifies their parts, and ſublimes them up. To this diſſolvent power its virtue of exalting the colour of gold may likely be attributed; for gold being melted with borax, obtains commonly a pale colour, but upon adding either ſome *ſalt-armoniac*, or ſome ſalt-petre, when in fuſion, it acquires a fine deep yellow colour; yet theſe two ſalts muſt never be added both together, for then the ſalt-petre will deflagrate and ſpringle ſome of the noble metal away. **Salt-armoniac.**

away. *Salt-armoniac* and spirit of nitre make an aquaregis. (§ preced.)

Common salt. § 257. *Common salt* (⊖) being dissolved in water produces nearly the same effect as the dissolved salt armoniac. In that operation called *cementing*, the common salt is to be mixed with brick-dust, which being in a closed vessel or box exposed to a proper heat, its spirits are discharged, and the metals surrounded with this mixture, are dissolved by it; hence gold may be purified from other metalline mixtures by that means, in the dry way.

Nitre. § 258. *Salt-petre, (nitre)* (⦶) dissolves part of the metals in fusion; this appears by the exaltation of the colour of gold upon melting it with salt-petre, likewise by the refining of silver from its copper in fusion with the same salt, when the noble metal has been mixed with regulus of antimony. When, in the operation of cementing, the salt-petre is mixed with dry terrestreous ingredients, it operates then in a twofold manner: First, its spirit, being discharged by the fire, dissolves the metal, and then the remaining part, being of equal effect with the alcaline salts, produces the same effect.

Neuter-salt. § 259. *Neuter salts* being mixed with such substances by which their fusion in the fire is prevented, or if they do melt, their running together is obviated, and metals have been put in among this mixture by way of stratum super stratum, their acids will be discharged and therewith the metals dissolved in the same manner as they would do in the liquid way. Where it is remarkable that in this dry way the spirit of common salt will dissolve

even

even silver, which it never does in the liquid way; and even vinegar contained in the verdigris will then affect the silver. Gold alone remains unaffected of these salts, except if such ingredients be added to the mixture by which an aquaregis or an hepar-sulphuris is produced. This operation is called *cementing*, and the mixture *cement*, by which gold may be separated from other metals; yet not altogether but only in part. Cementing.

§ 260. *Borax* (🜻) dissolves all earths and stones in the fire when well ground and mixed together, and renders them to glass, which indeed succeeds with this salt the sooner, as it melts even by itself into the finest glass. But before it comes in fusion, it always foams very much up and is apt to run over if the vessel is not very large. The method to avoid this inconvenience is, to burn or calcine first the borax by itself in a very gentle heat, so that the crucible may become only half red-hot, when it first boils like pitch, then foams slowly up, and with that becomes a dry, fine, white substance easily to be rubbed to powder between the fingers. This powder has all the virtues of the solid borax, except that it raises no more up. *Borax* helps therefore for two reasons, the fusion of those metals which require a great heat of fluxing, such as gold, silver, and copper: First, when these metals are divided in small particles, such as file-dust, &c. the terrestreous dusty particles, which surround each of these small metalline bodies, hinders them from touching each other so close as to melt easily together, so that their fusion is very much prevented; and though they melt at last in a strong fire, yet they cannot perfectly unite into one lump, but remain for a great part entangled among these light terrestreous Borax.

Borax. treous particles upon the ſurface in ſmall grains. But when borax is added it reduces all theſe earthy particles into a glaſs, and removes therewith at once all theſe inconveniencies. Further, when metals are melted by themſelves, the fire, by its natural velocity, paſſes the metal too ſoon before it exerts its effect upon it, but the borax ſwimming on its ſurface, retains the heat, and by ſurrounding each particle of the metal on its ſurface, increaſes the effect of fire upon the metal, ſo that conſequently it ſooner comes in fuſion. This is at the ſame time the reaſon why imperfect metals may be kept for a long time from being deſtroyed in the fire, when melted with borax, becauſe it covers the ſurface of the metal and maintains it therewith from the effects which fire and air have when they both act upon the metal. From hence the prin-

Soldering ciple of its uſe in *ſoldering* ſuch metals, which do not flux in a ſmall heat, may be underſtood, ſuch as gold, ſilver, copper, and braſs. For, this operation being done with putting between the two metals, where they ſhall be joined, ſome borax and ſome metalline mixture of ſuch a kind as will flux much eaſier than either of theſe metals; the borax as ſoon as red-hot, fluxes and vitrifies the terreſtreous particles, and ſo cauſes that metalline mixture to melt and to unite with the ſurface of the other ſolid metal, and to join conſequently both together, leaving the reſt unaltered.

Phlogiſton § 261. The *Phlogiſton*, (🜍) or *Inflammable matter*, exiſts in all the three kingdoms of nature, (49, 50. 51.) and is always mixed with various other bodies, for which reaſon it is ſometimes of a more, ſometimes of a leſs fixed nature, (See diviſion II. chap.

chap. IV.) and consequently different in its dissolvent power.

§ 262. *Oils*, (☉☉) and *spirit of wine*, (🜅) agree nearly in their dissolvent quality. Oils,

The *Oils* will dissolve, what they dissolve.

1. Other oils, though some with difficulty.
2. Acid spirits.
3. Resins.
4. Most kind of gums, chiefly when of a resinous nature.
5. Sulphur, either by itself, or when united with semi-metals.
6. Lead and its calces.
7. Fixed alcaline salts.
(8. Copper and brass in some degree.)

The *spirit of wine* will dissolve, Spir. of wine, what it dissolves.

1. Water.
2. All wines.
3. All acid spirits.
4. All pure oils.
5. Most bituminous gums.
6. Pure volatile alcaline salts.
7. Fixed alcaline salts when perfectly dry.
8. Most kind of soaps.
9. Sulphur, when first dissolved in alcaline salt.

§ 263. All *imperfect metals*, as copper, iron, tin, lead, and semi-metals, except arsenic, lose their metallic form in a strong and long continued fire by themselves without any other addition, and are reduced therewith into a calx or powder; however those metals which require a great heat to their fusion, such as iron, copper, cobalt, Imperfect metals.

how changed, destroyed, regulus of antimony, must only be kept red-hot without coming in fusion: But tin and lead are destroyed or reduced into a calx, by keeping them only in a half red hot fire in fusion, when they soon loose their bright surface and collect a thin opake skin, which being drawn off with an iron hook, is soon succeeded by another, 'till all the metal is reduced into calx. Those calces being all collected, must be calcined in a slow open fire, 'till they admit of being rubbed to powder. Such metallic calces cannot be restored by fire alone into their metallic form, because they will either remain in the form of a powder, or flux into a scoria or glass; but upon adding a phlogiston, which is united with other substances in such a manner as to indure a sufficient heat before it goes off, such as charcoals, tartar, pitch, &c. this calx or scoria recovers then its metallic or semi-metalline form again; and the same may be repeated as often as desired. and restored. It is however to be observed, that never the same quantity of metal is recovered, but always part of it lost, so that the whole may be at last destroyed, when the same process is often repeated: This loss is either more or less, according to the difference of metals, to the strength and continuance of the fire by their calcination, as well as by the reduction, and to the different quantity and fixity of the employed phlogiston. From this principle, and because tin will melt even before oil begins to evaporate, depends the utility of oily and greasy substances in the art of tinning the iron, because they preserve the tin from losing its metalline surface in this operation. Tinning iron. And from the same reason the mixing of great quantities of charcoal along with the ores in

great

great ſmelting furnaces, helps to their reduction as well as fluxing, becauſe they reſtore with their phlogiſton theſe metallic particles, which at their roaſting have been reduced into calx by the fire and by the ſulphureous acids, into their metallic form. Phlogiſton

§ 264. From this effect and diſſolvent power of the *phlogiſton*, it has been conluded, that it conſtitutes even a ſubſtantial ingredient of the metals and ſemi-metals themſelves. The ſame concluſion has been made from the detonation of ſalt-petre when thrown upon the heated metals, and likewiſe from its being then changed into an alcaline ſalt, deſtroying therewith the metal into a calx or ſcoria. a ſubſtantial ingredient of metals

To this comes further, that the fumes which riſe from a ſolution of zinc or iron, made with a diluted oil of vitriol, inflame by the approaching of a lighted candle, and detonate with a loud report.

§ 265. *Common ſulphur*, (🜍) which conſiſts of a phlogiſton and of the vitriolic acid, is not only by itſelf, but when united with a fixed alcaline ſalt, a diſſolvent menſtruum of ſeveral bodies. Sulphur

§ 266. *Sulphur* by itſelf does not diſſolve gold when this metal is pure, but burns away and leaves the gold unaffected. So does it likewiſe not diſſolve zinc, when pure; but all the other metals and ſemi-metals are diſſolved by ſulphur in the fire. Silver is rendered a very fuſible ſubſtance by it. The mixture ariſing from pure ſilver and ſulphur is ſomewhat malleable, of a foliated texture, and much like lead in appearance; but with a long continued melting heat, the ſulphur goes off and diſſolves metals

Sulphur with metals, leaves the silver behind. Lead and tin detonate with sulphur, become difficult to flux, and grow brittle, and in appearance like a semi-metal. By this operation, part of the tin turns into a scoria, and may, by adding more sulphur, at last all be reduced into scoria. Copper is dissolved with sulphur in fusion as well as when only kept red-hot, and upon being exposed to a continued slow fire, it crumbles at last into a dark brown powder. Iron made red hot, and touched only with a piece of sulphur, drops down like water in a spungeous scoria, and is consequently rendered very fusible therewith. Sulphur may be driven out from iron better than from any other metal, by fire alone; because this metal suffers a greater degree of heat before it comes in fusion than other metals. When therefore other metals and semi-metals shall be freed from sulphur by means of fire, the heat must be given only in such a degree as they may not come in fusion; for, whenever this happens, then all parts of the mixture are united by their fluxing so as to maintain each other against the intended effect of the fire and air. For this reason it must be carefully avoided, that by the roasting of ores, in the great way as well as in assays, they may not bake together and begin to melt, and if this accident is observed to happen, the ores must be taken out immediately and grinded again. Regulus of antimony is with more difficulty dissolved by sulphur than any of the above-mentioned metals; it succeeds however at last by the assistance of mechanical motion; the mixture obtained looks like a crud estriated antimony. with arsenic. Sulphur dissolves the arsenic, and the mixture becomes according to the reciproque proportion, either a yellow, red, reddish or orange transparent

transparent colour. By the first colour it is called *sandarac*, (raushgelb), by the others, *sulphur-ruby*, *arsenic-ruby*. Sulphur.

§ 267. *Sulphur* dissolves one sort of metal more readily than the other; when therefore united with one metal, and then another metal is added to the former, which it unites better with, the sulphur leaves the former and unites with this in the fire. This constitutes the principle of that art which is called the *separating* or *precipitating* of metals *in the dry way*, which takes place equally in the great, and in the small way. Hence the silver may be parted out of the vitreous-ore, and the lead separated from its common potter-ore, only with adding iron; and therefore iron scoria are sometimes used in the smelting business, because they contain some iron; or only such ores as contain iron. For this reason the pyrite are of great utility in the rough-melting, because they contain a great deal of iron. The order or proportion how metals precipitate one another, is this: Regulus of antimony is precipitated with lead as well as with tin. The lead may be precipitated out of the sulphur, in some measure with tin, but much better with copper. Copper and all other metals and semi-metals are precipitated or separated from the sulphur with iron; and an equal quantity of sulphur requires more copper than iron, but still more of all the other metals than of copper to its solution. In general it must however be observed in this precipitation, 1. That always the scoria which swims on the surface contains the metal which has effected the precipitation, united with the sulphur, which scoria proves either fusible or refractory, according as the metal contained therein

Theory of precipitation in the dry way.

Sulphur. constitutes either a fusible or refractory mixture. 2. That this separation, except when made with iron, is never perfectly exact, because the precipitated metal retains always part of the other by which it was precipitated. Lastly, when mercury is dissolved and sublimed with sulphur, it produces *cinnabar.*

Hepar-sulphuris. § 268. *Sulphur* unites in fusion with the fixed alcaline-salt and dissolves that. This mixture, called *hepar sulphuris*, is so powerful a dissolvent, that by it all earths and stones, as well as those metals which require a great heat to their fusion, even gold and silver, are dissolved, so that they lose all metallic appearance, and will even dissolve in water. As therefore *sulphur* consists of a phlogiston and a vitriolic acid, these two substances may happen in various manners to unite with the fixed alcaline-salt, so as to produce therewith that hepar-sulphuris often where it is least suspected.— So will, for example, from a vitriolated tartar, or from any other neutre-salt which contains a vitriolic acid, arise such an hepar-sulphuris, by the mere addition of some tolerably fixed phlogiston, such as charcoal dust. From hence we may discover the cause why assays prove often so uncertain, and that some assay-masters will obtain metal from an ore, of which another can make nothing. It is therefore needful to observe and examine every ingredient of the ore as well as of the imployed fluxes with respect to their effects, in the art of assaying. However that sort of alcaline-salt which is made of salt-petre alone, as well as that made of tartar and salt-petre together, does not produce so strong a hepar-sulphuris with the sulphur.

§ 269. Ar-

§ 269. *Arsenic* (o-o) dissolves iron, and makes with it a white but very brittle metal. Copper dissolved by *arsenic* grows likewise white and remains pretty malleable; but if too much arsenic has been added, the copper turns brittle and its colour black when exposed to the air. *Arsenic* melted with tin, crumble both partly to ashes, which still contains a great deal of the arsenic; but that part of tin which retains its metalline form is of a very bright colour and of a foliated texture, it has very much the appearance of zinc, but nothing of its properties. Lead in fusion with *arsenic* begins in a slower fire and sooner to fume and to work than when by itself, and then one part goes off in thick fumes, the other turns into a soft yellow-reddish glass, and the remaining part of the lead, is brittle, and of a darkish colour. Silver is entirely penetrated by *arsenic*, becomes brittle, and when exposed to a strong open fire is partly carried off by it: in a closed vessel silver and arsenic, with adding some sulphur, make a reddish mixture. Gold with *arsenic* becomes brittle, loses its colour, and part of it is carried off when exposed to a strong open fire. *Arsenic* unites difficultly with cobalt, and the mixture obtained therewith is of a blackish and shining colour. *Arsenic*, like sulphur, unites best with iron, after this, with copper, after this, with tin, then with lead, and the last with silver. Consequently all metals may be freed from arsenic with iron, and in a measure be refined therewith. Bismuth will not unite with *arsenic*. Some kind of stones may partly be dissolved with arsenic, such as the calcareous and vitrescent sort, and assists their fluxing.

Arsenic with iron, with copper, with tin, with lead, with silver, with gold, with cobalt.

§ 270. *Regulus*

Regulus of antimony. § 270. *Regulus of antimony* (♔ ♁) dissolves, like the sulphur and arsenic, first and best, the iron, then the copper, and after this the other metals. Yet the mixture of regulus of antimony with iron, and that of the same semi-metal with tin, and likewise with zinc, weigh less than they should in proportion of their quantity. In contrary, a mixture of regulus of antimony with silver, and of the same with bismuth, with lead and with copper, grows heavier than they were before in proportion. It is observable, that a mixture of regulus of antimony with iron, is not attracted by the magnet, which however any other metallic composition with iron will do in some degree. It is therefore the easiest way to part the copper from iron, with adding some regulus of antimony to the mixture, because it swallows the iron up and destroys it in fusion: when afterwards the regulus which now contains the copper pure, may be blown off as usual. However, as the regulus of antimony goes off in fumes, it may carry off some part of the metal. *Regulus of antimony* dissolves readily with *cobalt*. The *regulus* when broke in small pieces, and calcined in a gentle heat, crumbles into a calx, which in a strong fire fluxes into a hyacinth-coloured glass, and this being fused again with a phlogiston, recovers its former reguline metallic form. Glass of antimony. This glass is one of the strongest dissolvent menstrua in nature; it fluxes all kinds of stones, destroys the metals, and rendes them into a scoria; the only gold excepted, which therewith, as well as with the regulus itself, may be refined from every foreign

admixture

admixture. From hence it appears, that the antimony may not altogether so well be separated from the other metals with fire alone, because it destroys and renders part of them volatile in a strong open fire.

§ 271. *Cobalt* (K) dissolves all metals and semitals, but lead and silver difficultly, and only some small part of it. For, upon melting lead and cobalt in equal quantity, both metals are found only sticking together, the lead as the heaviest at the bottom, and the cobalt above; so that it seems as if they had not at all mixed together. And yet when this cobalt is melted with iron, as the metal wherewith it unites the most readily, there remains a little regulus of lead at the bottom, because lead never unites with iron.— And so it seems likewise as if silver and cobalt did not at all dissolve each other; because when one part of silver is melted with two parts of cobalt, the silver has collected at the bottom and the cobalt above, sticking but together like different bodies, only that the silver is grown brittle and its colour somewhat greyish, and that of the cobalt rather whiter: yet when this silver is brought upon the test, the signs of cobalt appear plainly by collecting round the test, and one eighth of the weight of silver is missing, which is found upon assaying the cobalt upon silver. In general, cobalt renders other metals brittle, and cannot deprive the bismuth of its foliated texture, though they unite very well together. Cobalt.

§ 172. *Bis-*

Bismuth § 272. *Bismuth* (W) dissolves the hard fusible metals and likewise semi-metals in that manner, as to make them much sooner flux in the fire than they would do by themselves, yet renders them in the same time brittle. It dissolves neither arsenic nor zinc, whatever means may be employed; settling itself as the heaviest at the bottom, and leaving the zinc uppermost; yet they stick very fast together; whence this mixture proves of the same weight as each metal had before in proportion. The mixture of gold and bismuth, of silver and bismuth, likewise with lead, with tin, with regulus of antimony, is heavier than they should be in proportion to their quantity: that of iron is lighter, but that of copper and bismuth is equal to its former weight. Lead and mercury may be united with the addition of bismuth; and this addition produces such an intimate solution of these two metals, that great part of the lead will even go through the leather with the mercury:—From this secret arises that practice by which the mercury is so often adulterated with lead.

Zinc § 273. *Zinc* (X) dissolves all metals and semi-metals, except bismuth, and makes those metals which require by themselves a strong fire to their fusion, to flux in a very moderate heat. The mixture of gold and zinc, silver and zinc, and that with copper, likewise with lead, is heavier than it should be in proportion: but that of the zinc with tin, with iron, and with regulus of antimony, is lighter than it should be in proportion. Zinc melted with copper renders it yellow: this, when done with a zinc-ore, such as lapis-calaminaris, or black-jack, (blend) then

Brass it is called *brass*, which is much more malleable than when

when zinc and copper are melted together each in its metallic form, which latter mixture is called *prince-metal.* Zinc ſublimes in the fire, either in its metallic form,(in cloſed veſſels) or into flowers or calx, when burnt in an open fire; and with its fumes it is capable to carry off the metals with which it is united, wherefore it is reputed of a rapacious nature. That ſubſtance which collects in the great ſmelting furnaces of braſs founderies, called by the Germans *oven-bruch*, conſiſts moſtly of ſuch flowers of zinc, and acquires a ſhining phoſphoric appearance, the ſame as the red blend does when rubbed with ſome hard matter. Any of theſe ſubſtances being ground to powder under water, ſo as may be done in a mortar, with a tranſparent peſtle of glaſs, this phoſphoric light appears plainly in the water.

§ 274. *Lead* (♄) diſſolves all metals; only with the iron as long as that is in its metallic form, lead will not unite; but when both are reduced to a glaſs or ſcoria, they unite then very well. Lead may therefore be ſeparated from other metals with iron, if they do not unite better with lead than with the iron. The mixture of lead and gold, and of lead and ſilver, is heavier, but that of lead and tin is lighter, than they ſhould be in their proportion. In a ſtrong fire, lead turns into a fuſible glaſs or ſcoria, called *lytharge*; this, and every calx of lead, diſſolves all earths and ſtones, as well as the deſtroyed metals or calces of metals, and becomes with them a ſoft fuſible glaſs, if it contains but a ſmall quantity of terreſtreous particles. And then this glaſs being of ſo very ſoft and fuſible a kind, is able to diſſolve and to vitrify ſtill ſome more particles of terreſtreous matter. Lead

The

The softer therefore and the more fusible this glass of lead is, the sooner it will eat through the crucibles. Lead and tin being melted together, and this united mixture exposed to a stronger fire than its fusion requires, they both are soon vitrified, by collecting continually on the surface a red-hot calx, so that in a short time a great quantity of both these metals may be destroyed.* Lastly, *lytharge* helps the fluxing of these metals which require a great heat to their fusion, by the same reason as borax does, and may therefore be used to the melting of gold and silver without prejudice, as these noble metals will never vitrify or turn into scoria.

Tin § 275. *Tin* (♃) dissolves every metal, and renders it brittle; lead and iron the least, but gold and silver the most; so that the very fumes of tin render the gold as brittle as a glass. Tin is therefore added to copper to make a kind of hard metal, called bell-metal, used for bells and great guns, as requiring a greater hardness. The mixture of *tin* and silver, and of *tin* and copper, is heavier, but that of *tin* and gold lighter than they should be in proportion to their quantity.

Copper § 276. *Copper* (♀) dissolves gold and silver, and renders these metals harder, but not brittle, and consequently more useful for wear. It dissolves with difficulty the iron, and unites but partly with it in fusion, when its red colour becomes much paler of it: the remainder of iron settles in a separate regulus, sticking however very fast to the copper. The mixture of *copper* and *silver* is heavier, but that of *copper* and *gold* lighter than it

* This calx contains equal parts of both metals.

should

should be after the proportion of their quantity. Gold and silver are apt to lose their softness by the least admixture of other heterogeneous matter; even by the fumes of a bad-burnt charcoal. But when they are allayed in a just proportion with copper, this inconveniency does not easily happen.

§ 277. *Gold*, (☉) *silver*, (☽) and *iron* (♂) dissolve each other; and the mixture of *gold* and *silver* is nearly of the same weight as it should be in proportion to their quantity; it being found by experience that it weighs but a very little above it. The mixture of *gold* and *iron* becomes indeed something lighter than it should be in their proportion, yet gold unites with the iron extremely easily, and renders the iron more fusible; hence gold serves better than copper for soldering the finest instruments of steel or iron. Gold, silver, iron,

§ 278. *Mercury* (☿) dissolves gold, silver, lead, tin, and zinc, bismuth pretty well, copper somewhat more difficult, and more so the regulus of antimony, but iron and cobalt not at all. The solution of the regulus of antimony succeeds not in the common way by trituration, but it must first be melted, and in fusion poured in water to the hot mercury. But when the regulus of antimony has been made with iron and an alcaline earth, the solution succeeds then better with the mercury, and so the regulus remains united with the mercury, without being expelled again after some time, as it happens in the first way. Mercury

This

Amalgamation

This method of dissolving metals with mercury, is called *amalgamation*, and the dissolved metal an *amalgama*; and represents always a white and thick substance, because the mercury being impregnated with the dissolved metal, loses therewith its fluid form. The amalgama of silver grows heavier than both metals should weigh in proportion to their quantity; wherefore this amalgama does not swim when thrown in current mercury, but falls to the bottom. The superfluous part of mercury may indeed be pressed through a leather, and so separated from the amalgama; but that which remains in the leatner with the metal, and which is nearly as much as the dissolved metal, must be separated with fire. When but a very little part of metal is amalgamated with mercury, it unites so intimately with that, that not only it passes with the mercury through the leather, but will even rise over with the mercury when driven with a strong fire: it may however mostly be recovered when the distillation is performed with a very moderate equal heat.

CHAP.

CHAP. VI.

OF THE CHYMICAL APPARATUS.

§ 279. BY *chymical apparatus* are underſtood those inſtruments and veſſels by which the chymical agents, *fire*, *air*, *water*, *earth*, and the *diſſolvant-menſtrua*, perform their intended effect upon the bodies. Chymical inſtruments

§ 289. The *laboratory* is a place where the chymical operations are performed. This muſt be ſpacious, light, airy, a ſtone-building, and provided with chymnies of a good draught. Laboratory

§ 281. Thoſe inſtruments or veſſels in which the fire is made for the various purpoſes of this art, are called, *furnaces*. Now as chymical operations require partly a different degree and uſe of fire, partly a different continuance of it, various conſtructions of chymical furnaces have been invented, whereof ſome have been communicated with great exactneſs by chymical authors, ſuch as in *Boerhaave's Chymiſtry*, *Cramer's Docimacy*, *Ludolph's Chymiſtry*, and others. Furnaces

Commonly a *chymical furnace* has two partitions or chambers, the firſt and lowermoſt, is called the *aſh-*

Furnaces *ash-sink*, and reaches from the bottom till to the grate upon which the fire burns. The other begins at that grate and contains the coal or fuel itself with all the heat raised therin, together with such vessels as are exposed to that heat for obtaining such alterations or effects as intended; and this is called the *fire-place*. To this partition are sometimes added a third and fourth chamber, into which the flame and heat is led from the first, the fire-place. By reading the above-mentioned authors, and lending attention to all that has been said above of fire, in the first chapter of the second division, any one may form not only a pretty clear idea of these furnaces and of their effects, but be able to order the construction of such furnaces himself to any intended purpose, so as likewise to change their construction according to different intentions. We shall therefore give only the best and most useful of these furnaces, and explain them with their plans and desciptions.

Blast furnace. A *blast furnace* is, where, by the compression of air through bellows, the force of fire is raised.

Draught furnace. A *draught-furnace* (in German, *wind-oven*) is in general called that, where, by the elastic power of air, and by the velocity of its pressing in through the ash-hole, directly upon the grate and the fire lying thereupon, the heat is raised within the furnace to a great degree.

To this species of draught-furnaces belong the following, viz.

The

The *Assaying furnace*, *Tab.* I. *Fig.* 1. which after Cramer's information is made in the following manner, viz. Assaying furnace Tab. I. Fig. I.

1. A rectangular prism is made of plate-iron, eleven inches wide and ten high, *a. a. b. b.* which, seven inches farther on at the top, from *b.* to *c.* is sloped off so as to represent a romboid cone, and leaves the cone at its extremity, a rectangular opening of seven inches square, in *d. c. c.* Lastly let a bottom of plate-iron be made to it, in *a, a.* its construction.
2. In the breast-wall, at the bottom, a hole is cut out in *e.* three inches high, and five wide, which is the ash-hole.
3. Above this, six inches from the bottom, another hole is cut out in the form of a semicircular arch, whose basis is four inches, and its elevation or radius, three and a half. This is the muffle-hole. *f.*
4. In order to shut or open these holes, No. 2, and 3, according to the nature of the operations performed in this furnace, sliders must be applied on each side of these holes, that is two sliders for the ash-hole in *k. k.* and two for the muffle hole in *l. l.* To this purpose let a seam of iron-plate be rivetted, first at the bottom in *a. a.* about half an inch broad, and as long as the furnace, having a grove all along its uper edge in which the slider may draw backwards and forwards; and then another such seam of iron-plate being rivetted to the breast wall in *b. b.* likewise with a groove downward, which will receive the

 same

Assaying furnace.

same slider at the upper end, both sliders *k. k.* will move easily backwards or forwards, so as to shut or open the ash-hole as may be required.

This seam of plate-iron *b. b.* must be about three inches broad, in order to have another grove on its upper end, and to receive therein the uppermost sliders *l. l.* Lastly a third seam, is rivetted at the upper end of the furnace, in *b. b.* which like the lowermost is but about half an inch broad, and fitted to receive in its grove those two sliders *l. l.* with their upper edge. These two sliders must move likewise easily in their groves, in order to shut or open the muffle-hole *f.*

5. In one of the upper sliders *l.* at the left-hand, let a small hole be cut out in *m.* which is but one fifth of an inch high, and one inch and a half long. In the other slider on the right-hand, another hole is cut out, in a semi-circular form, whose radius is half an inch, in *n.* Lastly, let a ring or holder be made to each slider by which it may be moved.

6. Near the basis of the muffle-hole *f.* let an iron grasp be rivetted on, which serves to hold a little table of plate-iron, whose figure is represented in *β.* This little table is five or six inches long, and four broad, and has an edge bent up on each side; likewise a broad hook in *γ.* which fits the iron grasp in order to hang steady before the muffle-hole, like a table or stand.

7. Let

7. Let two ſmall round holes about three fourths of an inch be cut out in the breaſt-wall juſt underneath the muffle-hole, in *o. o.* which will be juſt five inches diſtant from the bottom, and three and a half from each of the ſide walls; two other ſuch holes muſt be cut exactly at the ſame dimenſion in the oppoſite back-wall, becauſe they are to receive two iron-bars, upon which the muffle muſt reſt horizontally. Another round hole one inch diameter is then made juſt above the upper ſeam in *p.* which is only for air, and to ſtir the coals. Aſſaying furnace,

8. Let here and there, at the inſide of the furnace little iron hooks be rivetted on, about half an inch long to hold the lutum or clay of which the furnace is luted out within.

9. Let a ſquare cover *q.* be made which fits the upper end of the furnace, being about three inches high, and ending at the top in a round pipe *r.* thee inches diameter and as long; this pipe or orifice ſerves to receive another pipe *t.* which may be taken off or on, therefore that pipe in *r.* muſt be ſomewhat ſlopy towards the top; that pipe *t.* ſerves to raiſe the heat when required, by cauſing a ſtronger draught. The cover *q.* muſt have two handles or hooks to lay hold of when taken off, or put on. In order to make that cover *q.* ſtand ſteady, as it muſt do by handling the pipe *t.* off or on, a ſtrip or ſeam of iron-plate may be rivetted on at the top of the furnace on the right and left edge, in *c. c.* in which the cover may gripe in and hold faſt, and likewiſe be ſlided gently backwards and forwards in that groove, by taking it off or putting it on.

 10 Juſt

Assaying furnace,

10. Just above the ash-hole, about three inches and a half from the bottom, a frame of strong iron plate, one inch and a half broad, is laid all round the inside of the furnace, upon which the iron grate, as well as the lute is to rest. This frame must consist of two pieces, in order to be easily fitted and laid into its place; the ground upon which that frame is to rest, are a number of iron pins, each one inch long, to be riveted on all round within the four walls, about four pins to each wall, just at the above heigth of three inches and a half from the bottom; and so the assaying furnace is ready to be luted out, which is to be done as follows: viz.

In order to lose less of the heat, and likewise to keep the iron plate from being soon destroyed by the violent heat, all the four walls are laid over with lute an inch or an inch and a half thick, from the frame or grate up to the top. This lute is the same of which muffles and clay-tests are made, being mixed only with water, or about one third or fourth part of oxen blood among the water. Before you begin with laying on the lute, the first is to put in the frame, then upon this the grate; this is made of square iron bars, half an inch thick, which are laid three quarters of an inch distant of each other, not on their flat side, but on their edges, by the help of the lute, for, if laid flat they are soon filled up with ashes and cinders which hinders the air from having a free vent, but when laied on their edges, this inconveniency is easily prevented. The lute being thus laid on every where, and well dryed, the furnace will serve to all operations which are

are done under the muffle. When you go to work with it, let it be set upon a herd under a chimney at least four or five feet high from the ground, in order to look in conveniently at the work without stooping, because these operations require a constant looking in upon the work in the muffle. Having put in the two iron bars through the holes in *o. o.* which must reach fully through the furnace from the fore-wall to the back, so as to reach out each way about an inch, lay the muffle-plate in upon the bars, and then set the muffle upon its plate, so as to stand close to the fore-wall, and about one inch and a half distant from the back-wall; and in order to prevent the muffle from moving off from the fore-wall, fasten it with a little lute to it within-side. The muffle is brought in through the top of the furnace, and so are the coals which you use for firing, wherefore the cover *q.* must take off easily and fit well. The best fuel for this furnace are coals of hard wood, chiefly of beech, and not much larger than an inch, because if smaller they hinder the draught, and burn out too soon, and if larger they cannot fall down to the grate, the room between the muffle and the side-walls being but about an inch and a half; and if any place remains empty of coal between the muffle and the walls, the heat is rendered uneven and the work entirely hindred from going. **Assaying furnace,**

As the operations performed in this furnace require a pretty careful management of the fire, the following instructions how to raise or lessen the heat must be attended to. viz. **how used.**

1. The furnace being filled with coal and lighted, the heat is increased by opening the ash-

Assaying furnace, hole, *e.* (*Fig* 1. *Tab.* I.) then shutting the muffle-hole *f.* by drawing both sliders close together; further by putting on the cover *q.* and lastly by applying the draught-pipe *t.* at the top, for then the heat will be raised to a great degree.

how used. 2. In case a strong heat is quickly required to play directly upon the work contained in the muffle, this is obtained by hanging the little table *β.* on the muffle-mouth *f.* and then, the sliders being opened, lighted coals are laid upon the table, which by the draught of air, fill the muffle with a great heat. Yet this method is seldom required except in the beginning, when you desire the work quickly to grow hot; and sometimes in wet seasons, when the moisture of the air retards and slackens the draught and consequently the heat. From these means of raising the heat appears now likewise the method how to lessen it. It will then be lessened,

a. By removing the coals and table before the muffle-mouth.

b. It will be lessened a great deal by taking off the draught-pipe *t.* from the cover.

c. But a small degree of lessening the heat being required, this will be obtained by drawing the slider *l.* with the oblong small aperture *m.* before the muffle-mouth; and it will be lessened a degree more by removing that and pulling the other slider with the semi-circular aperture *n.* before the muffle-mouth.

d. Further

d. Further to lessen the heat at once considerably, this is done by taking off the cover *q.* and

e. In order to cool the whole furnace quickly, the ash-hole must be shut up, drawing the two sliders *k. k.* together; which, when the muffle-hole is left open, cools the work so as to stop its going entirely.

If during your operation the heat should begin to fail on one side or the other, which you will observe by the muffle growing dark somewhere, it shews that the coals do not lay even round the muffle, and that some corner is empty of fuel; and then you must make use of the iron rod, as mentioned above, introducing it through the round hole *p*, to stir down the coals and fill up the vacancy. Sometimes the air draws stronger on one side than on the other; in that case you may apply a little instrument, *Fig.* 17. *Tab.* I. which being set to the side where it draws most, it will lessen the heat, and make it go equal.

A *Melting furnace* is, where crucibles and melting pots are set into the fire-place itself in the midst of the burning coal, and thereby the heat be raised to such a degree as to melt any object contained in the melting-pot. Melting furnace

Tab. II. *Fig.* 1. represents a *melting furnace* of D Ludolph's invention, joined with an athanor, and is made in the following manner. Tab. II. Fig. 1.

An

Ludol. melting furnace

An Athanor of four or five feet high being built, with its grate in *c. d.* and at its side a melting-furnace, *e. f. b. i. g.* having a brick walled in, in *m.* upon which the crucible is to stand: then the furnace *a. b. k.* is filled with coals; and being first walled-up in *k.* the fire is made upon the grate in *c. d.* when the coals will rush down successively upon *a. c.* through the opening *c. b.* upon the grate *c. d.* and then the air being let in through the grate *n.* draws the flame briskly into the furnace *e. d. b. i.* and out again through *g.* so that in less than two hours the whole furnace *e. d. f. b. i.* becomes thoroughly red-hot; and as the coals slide only down by degrees, and consequently are always lighted at the furthermost part, the crucible can never crack from any cold air or coal, as is frequently the case in draught-furnaces. When the coals are mostly consumed, the athanor is only to be filled up again, by which means a melting fire may be constantly kept for many weeks or months. The great advantage of this furnace is, that therewith every degree of heat may exactly be observed and given, because the crucible is never exposed to the immediate contact of the fuel, but is only heated by the flame and draught of heat. If therefore less air is let in through *n.* it goes gently; and if more is let in, and the aperture *p.* shut by means of the door *o.* then it goes hot. If it goes too hot, let it be shut up in *n.* entirely, and remove the door *o.* and it will cool instantly. The reason why the grate *c. d* has not been laid directly underneath the athanor, is, to save a great deal of coal; for then the air would draw the heat too far into the athanor, and only waste more coals

to

to no purpoſe; which by that means is avoided, and yet all the ſame effect obtained.

A furnace in which things may be diſtilled, likewiſe ſublimed, or only digeſted, is called a *Diſtilling furnace.* **Diſtilling furnace.**

If the diſtillation requires a ſtrong fire, the retort, when firſt properly luted, is placed barely upon the two iron bars in the midſt of the fire-place, which being walled up at the top with bricks in the form of an arch, cauſes the fire to play back upon the retort, and thence it is called a *reverberating furnace.* But if the diſtillation requires a leſs violent, or but a gentle heat, a pot of iron or clay, inſtead of the retort, is placed upon theſe two iron bars in the fire-place, which pot is called a *coppel*, and in this coppel the retort is placed, either (naked) by itſelf, or by filling the coppel firſt with part of water, aſhes, ſand, iron-filings, and then it is called a *Coppel-furnace.* If the coppel is filled with water, it is named a *Balneum maris*; if with ſand, a *Sand-bath*, &c. **Reverberating furnace**

Fig. 3. *and* 2. *Tab.* II. repreſent theſe diſtilling furnaces, of which the latter may not only be conſidered as an athanor, but in the ſame time as a reverberating furnace; becauſe the flame is driven from the opening *f.* over into *g.* and likewiſe from the arched vault back upon the retort: an exact deſcription of both which may be ſeen in Ludolph's Chymiſtry, Part I. And ſo we muſt likewiſe omit, for brevity's ſake, the deſcription of Boerhaave's wooden diſtilling and digeſting furnace, *Tab.* IV. *Fig.* I, and his portable diſtilling and coppelling furnace, **Fig. 2. & 3. Tab. II.** **Tab. IV. Fig. 1.**

Tab. IV. Fig. 2. furnace, *Tab.* IV. *Fig.* 2. as the account thereof may be seen in his Chymistry, from pag. 886 to 891.

Ludolph. Athanor. But we shall give a description of *Ludolph's Athanor*, *Tab.* III. *Fig.* 1. and of *Cramer's glass-furnace*, as two very useful inventions. Ludolph gives the following description of his athanor.

Tab. III. Fig. 1. Let a square tower be built as high as to reach with its top *a*. up in the first story, in order to fill it always from thence with coals, without having occasion to handle them in the laboratory amongst the retorts and receivers. The bottom of this athanor may be made about six inches high, yet so that in *c*. a round hole about four inches diameter and five inches deep, is left. Then a square chamber is built up to *d*. and *e*. whose inside is fourteen inches square, and eight high, to which an ash-hole is made in *f*. From *d*. to *e*. a strong grate is laid; from *d*. to *b*. an opening of twelve inches high is left, and from *d*. to *g*. a circular bow is constructed, whose center is in *b*. From *g*. *b*. to *a*. a square tube (or chimney) is built up, whose inside in *g*. *b*. is fourteen inches, and at the top in *a*. is ten inches square. Its height from *b*. to *a*. is to reach just up through the roof, and the building of the furnace to be so contrived as to come out with its top in *a*. just at the side of a chimney, as the most convenient place to be filled with coal. In *i*. a little door is made six inches high, and eight wide, which serves to look into the coal, and likewise to push them down in case they should stick in the curve *g*. *d*. In *k*. an opening is left one foot square, and the rest built up to *l*. *m*. at which place the furnace is to be walled up, yet leaving

leaving in the centre of the top *l. m.* a round hole in *n.* to receive a small Coppel of cast-iron, about six inches wide and deep. Ludolph. Athanor.

At the bottom in *o.* and *p.* it may be left hollow, and then the empty place *o.* will hold very conveniently an iron roasting-pan which, when the fire grows pretty hot, serves very well for roasting and baking any meat therein; and the chamber *p.* is extremely proper for gentle evaporations.

The wall *q. s.* must have likewise an opening in *r. s.* of one foot square, through which the fire communicates from the athanor *a, b.*. Then the chamber *q. s. u. w.* is to be built, whose inside is fourteen inches wide,and two feet high. In its wall, a hole of one foot square is left, and at the top a coppel of cast-iron, *x.* walled in, of twelve inches diameter, and nine to ten inches deep. In *u.* another opening is left of one foot square, through which the heat circulates; and there again an iron coppel *z.* is walled in, of the same size as that in *x.* In *y.* another opening of one foot square may be made in the breast-wall. But to make now the fire rise up a little higher, the following part of the furnace is raised by a curve to *i.* leaving there in the iron-wall again an opening, 2. of one foot square, and in this furnace another Coppel of cast-iron, 3. is walled in. In the next part of the furnace, in 4. a copper for distilling is walled in. The bottom of this part of the furnace must again be raised half a foot higher from the former. And since here the large size of the copper requires the furnace to be wider, the bottom 5. 6. must be made of a square plate of cast-iron, which serves then to

convey

Ludolph. Athanor. convey the heat into the cavity underneath in 7. for baking fruits and making malt therein. In 6. another opening of one foot square is left; and to make some use of the remaining part of this iron bottom, another iron coppel is walled in there, in 8. From 6. to 9. a free passage underneath the furnace being required, iron-bars are to be laid from 6. to 9. paved with a double bottom of bricks. In this furnace a Coppel of plate-iron, 10. and an oblong square chest of plate-iron, 11. is walled in. The openings 12. and 13. are indeed not so high as the former, yet the draught is equally free, as being so much the broader, and leaving therewith as much room to the air as the former passages have; besides that the air being not much cooler, it wants no more so much room to play. In this furnace are walled in, two square chests of plate-iron, at 14. and 15. and as this number of furnaces was thought sufficient, the whole finishes with a little square tower or chimney, in 13. to 16. whose width is eight inches square within.

The chest 11. is continued so as to serve most conveniently for putrifying any substance therein, without having occasion for that troublesome dirty apparatus of horse-dung. In this chest is to be fitted a false bottom, pierced with many holes, and four or six iron feet fastened to it of about three inches long, in order to leave as much interval between the two bottoms. Then water is poured in as deep as to fill the chest two inches, which must be kept always in the same quantity, being let in through a funnel, in the manner as it is done with the balneum maris. Then saw-dust is laid upon the false bottom one inch deep, and as loose as pos-

poſſible; upon this the veſſel is placed, and the whole cheſt filled up with ſaw-duſt round it; by this means the hot ſteam of the water riſes up through the ſaw duſt, and keeps the veſſels always in an equal degree of heat, in a manner greatly ſuperior to horſe-dung, though ever ſo often changed, and may be kept in that manner ſo long as ever the putrefaction is intended: whereas with the horſe-dung it muſt be renewed every five or ſix days with great trouble and inconvenience. This cheſt has been found of ſo much uſe and ſervice in this buſineſs, as to pay alone the whole expence of the coals uſed in theſe operations. **Ludolph. athanor.**

It remains now chiefly to ſhew in what manner this furnace is to be managed and ordered, ſo that to each of the ſeveral operations which are all at the ſame time, and with one fire performed therein, the different due degrees of heat may be given; which may perhaps ſeem almoſt impracticable, as there is no other draught but that only one in *f.* from which the whole machine muſt receive its direction: whereas other furnaces of that kind have a little tower or chimney with a ſtopper or regiſter in *q.* and *w.* at each coppel, by which they think to let out ſuch heat as the operations in the next furnaces may be unable to bear. But as firſt, theſe many ſtoppers or regiſters render the conſtruction of the furnace very inconvenient and troubleſome:—Secondly, are very apt to cauſe miſtakes to the artiſt:—And yet, thirdly, produce by no means the proper and intended effect; becauſe, if for example, the copper 4. has its right degree of heat, and they would have the operations at 2. and 3. go ſlower, they could indeed let the heat

Ludolph. Athanor. heat out in *w*. but then the same copper, and all the rest of the furnaces would have no heat at all left. This is therefore the reason why none of these registers or stoppers are applied in this furnace, as being superfluous and even hurtful: instead of which every thing is directed by other contrivances, in such manner, that with much more convenience and exactness to each operation its proper degree of heat may be given, and that chiefly to the foremost operations in *x*. *z*. and 3. the heat may be lessened without taking away any to the furthermost operations.

To this purpose it will be of great advantage to consider first of all what degree of heat each operation may require or bear: for the construction of the furnace easily shews that in the vault *k*. the strongest heat is found that may be required for calcining, reverberating, and distilling; and that on the other hand the copper *n*. serves only to such operations which require a red-hot fire, such as for subliming, distilling, &c. In the vault *t*. may be distilled through a retort with a strong open fire, and other substances calcined and reverberated there with a lesser heat than in the vault *k*. In the Coppel *x*. may still be distilled in sand with a pretty strong heat. And in the room *y*. may likewise be distilled through a retort, with a good brisk heat. In the chamber 2. may be distilled through the retort in an open but gentle fire, and in the sand coppel 3. with a common middling degree of heat.

But in the whole furnace nothing was more difficult to judge than the placing of the copper *t*. in a proper manner, so as to have it neither too near

nor

nor too remote from the athanor *a. b.* For, if too near, and yet having a due moderate heat for it, the other coppels, 8. 10. 11. 14. 15. would have lost too much heat; and when too remote, the places in *n. x. z.* and 3. would have been too hot. Ludol. Athanor.

But experience has proved that this was the best place for it; for after having applied a Still with four pipes to this copper, two or three coppers full were immediately distilled off every day by that heat. The coppel 8. gives a balneum maris with so gentle a heat that the water comes not to boil.

The other coppels 10. 11. 14. and 15. have no more heat than what will serve for digesting, yet the nearest something hotter than the remotest. Each operation must therefore be put in that place and into that coppel which from hence is known to give to each its due heat, viz. Such as require a strong fire, in the coppels *n. x.* and those which require a lesser, in *z.* or 3. and such as admit but of a very gentle heat, in the last Coppels, 8. 10. 11. 14. and 15.

But there remains now the second advantage to explain, how one may give a very gentle heat even to the foremost coppels *n. x. z.* and 3. where the strongest heat is, and yet without taking away any heat, to the other operations in the furthermost chambers of the furnace. The chief advantage produced with that contrivance is this, that by this means one may put in fresh operations without letting the fire go out, and yet so that they may begin to work by gentle degrees, though the fire goes

Ludol. Athanor. goes on in the same degree without intermission. The whole art consists in this, to have made to each coppel of cast-iron another of plate-iron, fitting exactly the former, or if made of copper they will then serve in the same time to hold water for a balneum maris. For example, if you will sublime with a strong fire in the coppel *n*. put the vessel with as much sand as necessary in that coppel of plate-iron which fits the coppel of cast-iron *n*. down to the bottom, and it will very well sublime. But if in the same coppel you would make an operation which in the beginning requires but a gentle digesting-heat for some days, and only at the end a red-hot fire, then let your coppel of plate-iron but one-third or half down into the coppel *n*. being filled up so much with sand, and your work will have no more than a gentle digesting heat. When afterwards you require it to be red-hot, then let the coppel down to the bottom.

After the same means you may give less heat in the coppel *x*. than in that of *z*. with putting a Coppel of plate-iron in, and directing it higher or lower. For, though the coppel *x*. is mostly red-hot, that of plate-iron which is put into it cannot grow so hot until it is let down to the bottom. The same advantage may be had with the coppels 2. and 3. At the furthermost parts in 8. 10. 11. 14. and 15. those means need not to be made use of, because they have always a gentle heat: But at the fore-mentioned places it has, besides the former, this benefit, to keep the work and glass-vessels entirely safe from flying, because being always taken out along with the coppel of plate-iron, they remain hot, and may cool by very gentle degrees,

degrees, which could not be done in other furnaces without putting the fire quite out. The same benefit arises when fresh operations and new vessels are to be put in, where in the common way often many glasses are broke and accidents caused by too sudden a heat, all which is here entirely prevented, by putting the new vessels with the coppel of plate-iron but half and by degrees into the hot coppel. Moreover the degree of heat may be increased or lessened with the matter itself, in which the vessel is placed, as is sand, ashes, or water, and with putting them more or less deep into it. So, for example, you may give in the coppel *x*. a small, and yet at the same time in the coppel *z*. a great heat, by putting the glass of the coppel *x*. in ashes four inches thick from the bottom, and, in contrary, the glass of the coppel *z*. in sand only one inch from the bottom. This shews clearly how with the same fire various degrees of heat, in those several furnaces or chambers, may be obtained without hindering one another. Ludolph. Athanor.

In order to be fully instructed with the use of this furnace, I shall lastly shew in what manner it must be lighted.

The Athanor *a. b.* being filled up with charcoal and all walled up to the top in *a.* first of all a cement-work may be set in the hole or opening *c.* which I call the cementing-chest; this cementing-chest is greatly preferable to that which is given in the first piece, *fig.* II. partly because it is heated by a fire which performs so many other services, and furnishes this only as it were by accident; partly because it keeps it in a continual even degree

Ludolph. Athanor. of heat. For, there muſt naturally fall down from time to time ſome coals through the roſt *e. d.* whoſe bars by itſelf muſt be laid ſomewhat more diſtant than in ſingle laboratory-furnaces, in order to have always a free draught of air; and thoſe coals are ſufficient to keep the cement-box always red-hot. The cement-box being then put into the hole *d.* and covered with ſand as much as two fingers thick, the gentleſt heat may be given and kept in the ſame degree as long as ever deſired: if a greater degree is deſired, the ſand is only to be taken away. If the heat ſhall be ſtill raiſed higher, the cement-box is to be lifted up nearer to the roſt: and when quite lifted up, ſo as to reach to the grate, the work may even be brought to melt in the box.

In the chamber *k.* a retort may be put, filled with vitriol, which has been before calcined as uſual in a warm place; for, here being the firſt and greateſt degree of fire, all the oil of vitriol will be diſtilled over in three or four days. But if no ſuch kind of diſtillation is wanted, crucibles may be put into that place and any buſineſs for melting performed therein, the place being very convenient for a melting-furnace, ſuch as to make tincture of antimony, or whatever deſired. Beſides this it ſerves extremely well for a reverberating-furnace.

In the coppel *n.* either *cinnabar* may be ſublimed, or the *ſublimed mercury* as well as *dulcis* made. This coppel will likewiſe ſerve for coagulating and fixing the mercury by a continual heat of ten or more weeks time. A curious experiment was made in this

this part of the furnace with cinnabar, viz. three parts of cinnabar being mixed with seven parts of silver-calx, it was put to cement there for eight days, then other three parts of cinnabar were added, and again cemented, and this adding of the cinnabar in the same quantity repeated five times more, but neither a tincture nor any increase of the silver obtained. The room which remains beneath and at the sides of the retort in *k.* may be employed with putting crucibles there filled with salt of tartar, or nitre, or quicklime, and the salts will calcine and become caustic in the highest degree. Through the opening *t.* a luted retort may be introduced, filled with nitre and vitriol for making aquafortis; the places at both sides under the retort may be filled up with pieces of caput mortuum of which the spirit of tartar has been made, in order to calcine it into a good salt of tartar; or with ash-balls to calcine them for making coppels and tests of it. In the coppel *x.* oil of vitriol may be rectified in glass retorts in a sand-heat; or the arcanum tartari put in to purify it in the manner as shewn in § 9. But this place being the most convenient for its capaciousness, it will be most useful for rectifying the spirit of wine, first with pot-ashes, and then with rain-water, according to the method given in the first part: when the coppel must first be filled half full with ashes, then the alembic put into it, and the spirit will very gently distill over. Ludolph. Athanor.

In the vault *y.* an iron retort with hartshorn may be put; and in the coppel *z.* is the Balneum maris, into which stone bottles with vinegar are placed for making distilled vinegar. The vault 2. is

Ludolp. Athanor. is fit to hold an iron retort with tartar to distil the spirit and oil of it, and the coppel 3. serves for another Balneum maris to separate the phlegm of vinegar from the arcanum tartari, or from the acid tincture of antimony. In the coppel *t.* may be burnt a spirit of elder and juniper-berries, of wine lees, and stalks of grapes. Then several kinds of brandies and strong waters may be burnt therein; and if no other business remains for it, it may be filled with water, and kept for a Balneum maris.

The opening 6. is only made to clean the furnace. But in 8. a Balneum maris is kept which gives the right degree of heat for distilling the spirit of putrified urine. The coppel 10. serves for extracting and evaporating. The chest 11. is the place for putrefaction, very proper for making the salt of urine. The chest 14. will hold two alembics to make the true alcohol vini. And the chest 15. serves for digesting only in a very gentle degree, and for extracting tinctures and essences, and to make vinegar; in which case, however, the chest must be filled with ashes, and the vinegar-bottles only placed upon the ashes.

The only trouble happens with the retorts in the vaults *t. y.* and *z.* when after having finished the first operations, new ones shall be put in; and in that case it is unavoidable to leave the athanor for some hours without fresh coals, in order to make these vaults somewhat cooler, and to put in fresh retorts, During this time the other operations must cease indeed; yet they remain hot enough for being soon brought again to work. If no work remains for the vault *k.* for the coppel *n.* and for the

the cement-place *c.* then the coals may be saved by making only a wood fire in the vault *k.* at day-time, and at night with tanner's balls, in which case the opening *k.* must be walled up with bricks, and therewith all the other operations in the vault *t.* in the coppel *x.* and in the rest of the furnace, will be kept going. If but a few operations are to be made, the fire may be kept in the vault *z.* or even in that of 6. and then only the furthermost furnaces will be at work. Ludolp. Athanor.

This furnace is therefore adapted to perform all kinds of operations therein, in various manners and methods, without having cloaths and hands spoiled with a continual breaking and handling of coals: every operation comes soon to work; and more business may be done with this furnace during one winter, with all conveniency, than in the greatest laboratory in two years time. One load of coals serves for many weeks, which would be spent with two or three operations when kept as long in separate furnaces; so that, besides so many other advantages, it saves a great deal of coal: and if fired with wood, it costs but half the expence. And those who have convenience to build it in such a manner as to convey the heat into the rooms of the house, the chymical operations may come in to little or no charge at all.

This Athanor is still more corrected by the following alteration. (See *Tab.* IV. *Fig.* 4.) Tab. IV. Fig. 4.

Experience having proved that indeed a much stronger and better heat could be given with coals, than with wood and flame-fire; but then it was How corrected.

 found

Ludolp. Athanor. found likewise, that the iron-bars of the grate being laid close, the draught was soon stopped by the ashes and small-coal collecting there, and consequently the heat much interrupted: and when, on the contrary, the grate was too wide, the hottest and smallest coals fell too soon through it, by which the heat was likewise lessened. This has now been helped in the following manner, viz. to lay that grate not in a horizontal, but so as *Fig.* 4. *Tab.* IV. shews, in a perpendicular direction in *e. d.* For, so the coals falling down from the Athanor *a. b.* and the declivity *g. e.* into the room *d.* the draught in *e. d.* remains always free, and yet every little coal must serve and consume itself entirely before it can fall through that grate. Moreover there is from the door *f.* which communicates with the cement-place *c.* a slider made in the bottom *d. o.* by which as many coals may be let down upon the cement-box as desired. The rest remains in the same construction as before.

Tab. IV. Fig. 3. The glass-furnace, *Tab.* IV. *Fig.* 3. is after Cramer's principle, and constructed in the following manner:

A glass-furnace. To the matter of this furnace such stones must be chosen as will bear the strongest fire. This may be soon found out by using such a stone for a foot to a crucible, in which a strong fusion of copper or the like substance is made. For if this stone does not stick to the bottom of the crucible when taken out, nor shews any or but little vitrification, unless perhaps a thin vitrified crust; likewise if it contracts no chinks, and preserves its hardness when cold, then it may be judged to be good

good and fit for this purpose. But those which stand indeed the strongest fire, yet when cold crumble to pieces, are not fit for this use. And to the cement used in building of it, the same stuff may be used of which these stones, or that of which muffels are made. But the stones must be joined so close, that but a very thin strata of the cement may be laid between them. A glass-furnace.

The place in which this furnace shall be constructed, must have a chimney of a very good draught; every other large passage through which the air may pass too freely, must be shut up, and the furnace be built near this chimney in such a place, that the artist may have every where a free passage round it.

The outside of its form may be cylindrical, and the top arched; the outward dimension twenty-four inches diameter, or more, according to the size of the stones; its height must be forty-eight inches; the thickness of the wall, where it is least, four or six inches. The inside is divided into four chambers, constructed in a parabolic line.

The lowermost serves for the ash-sink, being twelve inches high, and its greatest diameter at the bottom fourteen inches, which gives consequently the construction of the parabolic line. This arch must have at the top in its centre, a hole of ten inches diameter, so that the remainder of its circumference makes only an edge or margin of two inches broad round the hole, and serves to support the iron-bars which give the grate to this furnace.

A glass-furnace. furnace. Those iron-bars, which must be square, and laid upon the edge, are then fastened with a stratum of the best lute of the same thickness with the bars, so far as they rest upon this margin; which strata must be made very even and smooth, because the crucibles and other vessels are to be placed thereupon. At the bottom of the ash-sink a square hole is left, six inches wide and four high, with an iron-door to be shut or opened occasionally.

The second chamber in which the fire and fuel is kept, is built upon the former, and of the same height and breadth, except in case the stones should not be of a kind perfectly durable in the fire; for then it must be made some inches wider, and this space luted over with a lute or cement that will bear the strongest fire.

This lute, if no other is to be had, may be made from pounded black crucibles, mixed up with the strongest clay that may be had. The arch must have at the top a hole of six inches diameter, at the circumference of which the arch shall not be above one inch thick; round the edge of this hole a bottom or pavement must be made of lute, four inches broad, which serves to hold such vessels as shall be put in.

In the circumference of this chamber, seven fire-holes must be made, equally distant; six of which are to be four inches square, but the seventh six inches, yet all shall terminate at the top in a semicircular arch. Their basis must begin two inches above the innermost margin or pavement into which

which the iron bars have been fixed, and which is to be confidered as the pavement of that chamber. Into the wall, at the bafis of each door or fire-hole, a groove muft be cut out one third part of its thickness at the above-mentioned interval. Each fire-hole muft have an iron-door hung on hinges in the fame manner as mentioned Part I. § 239, No. 4. and coated with a good lute two inches thick. When fhut, they muft fit the groove cut out to that purpofe as deep as the doors are coated. Laftly, a fmall hole fhall be left in each door, through which one may obferve the work in the furnace. Glafs furnace.

The third chamber, which is to be built upon this, is perfectly fimilar to the fecond, only that the arch fhall be two inches lower, and a fquare hole made in the arch, not in the middle but towards the fide, communicating from this into the fourth chamber.

The fourth and laft chamber, is as wide and arched as the former are, but only eight inches high. On the fide about two inces from the pavement, oppofite the fquare hole which comes out from the third chamber, a round pipe of plate-iron four inches in diameter is walled in, which ferves for the chimney of this furnace to let the fmoke and flame from thence out into that of the work-houfe or room. This chamber muft have an opening fix inches fquare, from the bafis of the chamber and juft in the middle between the above-mentioned fquare hole and the iron pipe; and an iron door, hung on hinges, through which the veffels are put in and taken out, and the door to be fhut or opened accordingly. Its ufe.

The

Useof the glass-furnace.

The use of this furnace is as follows: The fire is made in the second chambers, the fuel may be charcoal, or dry wood, chiefly that of fir, which is thrown in through the largest (the seventh) fire-hole. With regard to the fuel which shall produce a great heat, it must be observed:

First, if the greatest heat that can be raised by the draught of air shall be given to the body exposed to it, this is done when surrounded on all sides with, and in immediate contact of the fuel. Coals of a middling and small size must be chosen, and the foot or support upon which the vessel stands, not above three inches high from the grate, when the vessel is of a large size; but when it is of the smallest size, the foot shall not be lower than one inch.

Secondly, when the vessel does not admit of being surrounded and covered with the fuel, but must receive the heat only from the sides or underneath, which is the case in this furnace, then you make use of large coals and large wood.

If you have a hole cut through the wall of the work-house, or of the room, somewhat larger or at least equal to that of the ash-hole, and a pipe of plate-iron, or only of wood, is led from thence to the furnace, and all entrances of the house or room well shut, the draught of air through this pipe will increase in proportion as the chimney of the room grows warmer, and will at last raise the heat in the furnace to the intensest degree

degree that can be made by the draught of air; the greateſt heat will be about the fire-holes in the ſecond chamber, ſo that ſome ounces of copper being thrown into a crucible which ſtands there already heated, it will melt in one minute without any flux, and run clearer than is required to its fuſion for common uſe in caſting. The veſſels are put in through the ſeven fire-holes and placed upon the round margin or edge where the iron bars have been laid and luted in, and may be as many as there are doors. Theſe veſſels which you put in before the furnace is quite hot, may have feet or ſupporters of one inch thick to ſtand upon, but they muſt be of a good ſubſtance which does not eaſily vitrify in a great heat. The matter contained in the veſſels may be obſerved and examined through the little hole of each door. In the third chamber the veſſels have room to ſtand in a double row, twelve or more if they are not too large—in this chamber the heat is a degree inferior to that in the ſecond, that is, only of a middling melting heat. The glaſs-furnace.

Laſtly, in the fourth chamber, the heat is as gentle again, and moſt proper for calcining and roaſting ſuch things as require a moderate heat; for here the veſſels will only grow red-hot. When the furnace has been heated already, the veſſels which ſhall be put in, muſt firſt be nealed and then they will bear the heat of the fourth chamber, from whence, when red-hot, they may immediately be brought either in the third or the ſecond chamber.

Before this furnace is lighted, every intended operation ſhould firſt be ready prepared and at

hand;

hand; and then many experiments may be performed therein with little trouble, fire, and expence; and I confess that none have been more agreeable than those I have made in this furnace, though on account of so long continued and strong a fire they must have been very laborious and troublesome in other furnaces: And I say but little when I assure the reader that every thing is done ten times as easy as otherwise, when rightly and properly managed.

Chymical utensils. § 282. As for the rest of *chymical utensils*, it will be sufficient to mention only those which are mostly in use, and giving a figure of each.

In plate I.

Tab. I. *Fig.* 2. Is an *iron grinding-pan*, *a*. with a *grinding hammer*, *b*.

Fig. 3. A *clay-test*, is a small flat pot of clay in the form of a coppel, and serves for fluxing the ores with lead under the muffle.

Fig. 4. A *coppel*, and

Fig. 5. A *test*, for working lead; both are made of elixevated ashes, or of calcined bones.

Fig. 6, An *alembic*, is a vessel with an oval belly and a long neck; it is commonly of glass, but if the operation requires being exposed to an open fire, it must be of clay.

Fig. 7. A

Fig. 7. A *cucurbit*, (phial) has a round belly and a long narrow neck, and is mostly used for digesting. Chymical utensils.

Fig. 8. An *iron trevet*; it serves to hold a small phial, and to keep a few coals or a lamp underneath.

Fig. 9. A *helmet*, (still-head) is commonly a round hat of glass with a long pipe; it is applyed to an alembic in order to collect the vapours raised up by heat, from whence they run through the pipe into the receiver.

Fig. 9. *b.* Is a *perforated helmet*, having a small hole at the top, in which a stopper of glass is grinded in to fit very exactly; it is used to introduce some substance into the retort during the operation. A *blind helmet* is, what has no pipe or any aperture.

Fig. 10. A *retort*, is a vessel with a round belly and a neck bent downwards, and is used for distilling such substances which rise over with difficulty. Some are of glass others of clay.

Fig. 11. A *muffle*, *a.* with its muffle-plate, *b.* It is put in the assaying furnace, *fig.* 1. to receive the coppels and clay-tests.

Fig. 12. A *receiver*, is a vessel which being fastened to the mouth of the retort, or to the tubula of the helmet, receives the spirit and menstrua,

Chymical utensils.

menstrua raised by the fire. To the spirits of the fossil kingdom they must be of the largest size.

Fig. 13. *a.* A *joiner*, is a tubula fastened with one end to the mouth of the retort, and with the other to that of the receiver; its use is to prevent the splitting of the receiver in case the retort grows too hot. Some joiners are made with a belly provided with a small tubula, (*fig.* 13. *b.*) to which another receiver may be fastened, in order to receive therein separately the phlegm and sometimes the oil, which comes over during the operation.

Fig. 14. A *triangular crucible*, (others are of a circular form;) they are wide at the top, and narrow at the bortom. The *black* sort, called *ipser crucibles*, which consist partly of black-lead, bear the fire better than the other sort, and will suffer several times of being exposed to a melting-heat, only with this difference, that no kind of salt must be brought in, as their compound will easily be dissolved by that. In order to keep the crucibles from cracking during the operation, which happens fron the cold air pushing in through the iron grate, they must be put upon a foot or supporter made of a good clay, or such matter which will bear the strongest heat without vitrifying.

Fig. 15. A *copper-tute*, so called, is a crucible with a broad foot and long neck, and serves to collect the metallic regulus into a smaller compass

compass. They are originally made at Frieberg, in Saxony, and chiefly for assaying copper ores, and there called a *tute*. **Chymical utensils.**

Fig. 16. A pair of *grasp-tongs*, to hold the crucibles and melting-pots.

Fig. 17. An *earthen prism*, is used to put it at certain times in the muffel before the coppels, in order to make the work go cooler.

Fig. 18. A pair of *strait tongs*, to hold the coppels and clay-pots when put in the muffel or taken out: it is named in German a *klufft*.

Fig. 19. A *cone* is a strong iron pot, sometimes of brass or copper, in the form of a cone, being wide at the top, but ending in a narrow point at the bottom, and has a handle to it: it serves to pour the melted substances into it, and to make the heavier parts collect at the bottom into a regulus, leaving the scoria on the surface. Their properest size is four or six inches wide at the top, and six or nine inches deep; (or three by four.)

Fig. 20. *a.* and *b.* An *ingot*; it is an oblong piece of iron, or of other metal, in which one or more prismatic or spherical segments are cut, well polished, and smooth within, and serves to pour the melted metals into it, in order to have them in the form of long pieces, thence called likewise *ingots*. Some are of a small, others of a large size, according to the quantity of the metal.

Fig. 21. A

Chymical utensils.

Fig. 21. A *cementing-box*; it is a cylindrical earthen vessel with a cover fitted to it.

Fig. 22. *Aludels*, are round earthen pots, with a belly, and having a hole at the bottom, each of which fits exactly the mouth of that underneath. They are chiefly used for subliming mineral substances, such as flowers of sulphur, of antimony, &c.

Fig. 23. A *split-iron*, is an iron ring with a long handle, serving to cut off the necks of alembics, &c. when first made hot.

Besides these instruments there are many others required, such as *scales* and *weights*, an *iron ladle*, a *stir-hook*, *bellows*, *flat pans* of iron and glass, *hammers*, *anvils*, *files*, *chissels*, a *vice*, a *mortar* and *pestle*, a *washing-trough*, (in German, *sicher-trog*) for washing the ores, *shovels*, *wire* and *hair sieves*, &c.

Lute.

Some operations require the distilling vessels to be first coated with a lute when exposed to an open and strong fire: This compound is called *lute*, of which several compositions are given in *Rothen's Chymistry*, in *Lemery's Perfect Chymist*, &c.——For example: Take of loam or clay, ten parts; brick-dust, two parts; elixivated ashes, one part, and some short hair of animals; let all be well mixed, and make it up with water into a stiff clay: sometimes bullocks-blood is added to the water. With this matter the belly of the vessel, and so far as it is exposed to the fire, is to be coated over for about one-third of an inch thick, then laid to dry slowly in the air. Then take lytharge, two parts; red

red bolus, one part; fine sand, or powdered flintstone, one part; mix it well together; pour water to it, so much as to suffer of being painted with a brush over the former dried lute; then let it dry again.

To secure the slits of two vessels joined together with their necks, from letting spirits through, various sorts of paste are used, according to the nature of the objects. Sometimes only a paste of flower and water, spread upon paper or linen rags, will be sufficient. Another paste is made thus:—Take of wheat flour, and of quick-lime which has crumbled in the air to powder, of each one part; bolus half a part; make it up with the white of eggs mixed with water. After the operation is over, those plasters may be scraped off with a knife; or if the clue sticks too fast, soften it with wetted rags. Pastes.

Of the First and Theoretical Part.

DIVISION III.

Of Chymical Operations.

§ 284.

Chymical operations. THOSE performances which, by means of chymical agents and dissolvent menstrua, produce an intended alteration of certain bodies; that is, by which these bodies are either separated or compounded, are called *chymical operations*.

§ 285. Neither a chymical agent alone, nor a dissolvent menstruum without the chymical agents, can produce the intended alteration of a body: yet as there are some which contribute more, others less to the intended purpose, it will be proper to divide those operations according to the properties of both the chymical agents and the dissolvent menstrua, and to bring them in the following table.

TABLE.

TABLE.

CHYMICAL OPERATIONS

ARE CHIEFLY PERFORMED,

I. By means of FIRE: which are

1. *Fusion.*
2. *Draining*; called in German, *Sikering.*
3. *Burning* of *Silver.*
4. *Digesting.*
5. *Decomposing.* Which comprehends

A. *Roasting.*
B. *Calcining.*
C. *Subliming.* And this either

a. Into a fine powder, and then called *flowers.* Or
b. Into a solid compound, and then called *sublimate.*

D. *Distilling.* Which is either

a. Distilling over the helmet, (*per ascensum.*)
b. Distilling sideways, (*per latus.*)
c. Distilling *per descensum.*

E. *Evaporation.*
F. *Inspissation,* (*Coagulation*)
G. *Chrystallization.*
H. *Dephlegmation.*
I. *Abstraction.*
K. *Concentration.*

II. By means of Air: viz.

1. *Liquefaction* in the air.
2. *Impregnation* and *Exhalation*, (in German *Auswittern* and *Einwittern.)*

   A. *Vitriolising.*
   B. *Generation* of O *by the air.*
   C. *Generation of* ⦶.

3. *Solution of metals* by the air.
4. *Fermentation.*
5. *Putrefaction.*
6. *Gradation.*
7. *Crumbling of quicklime* in the air.

III. By means of Water: viz.

1. *Washing*, (in German, *Slemming.)*
2. *Elixivation.*
3. *Solution* of some bodies.

   A. *Edulcoration.*

IV. By means of Earth.

1. *Fixation.*

   A. *Partly.* Or
   B. *Wholly.*

V. By

V. By means of Dissolvent-Menstra.

1. *Amalgamation.*
2. *Solution in the dry way.*

   A. *Glass-making.*
   B. *Uniting in fusion.*

      a. *Making of brass.*
      b. *Soldering.*

   C. *Parting in the dry way.*

      a. *Precipitation.*
      b. *Scorification.*
      c. *Working upon the test.*

   D. *Reduction of metalline calces into metal.*
   E. *Reviving of* ☿.
   F. *Volatilising in the dry way.*

3. *Solution in the liquid way.*

   A. *Precipitating.*
   B. *Extracting.*
   C. *Cementing.*
   D. *Volatilising* in the liquid way.

An explanation of Chymical Figures.

🜂 Fire.

🜁 Air.

🜄 Water.

🜃 Earth.

Vitrescent stones of the refractory kind, transparent pebbles, horn-stone.

Fusible vitrescent stones, white opake quarz, glass-spar.

Clay, and argillaceous stones.

Plaster and gypseous stones.

Lime and calcareous stones.

🜊 Acid in general.

🜋 Acid of vegetables, or vinegar.

🜌 Distilled vinegar.

+ ⊖ Acid of common salt.

+ ⦶ Acid of nitre.

Acid of vitriol.

Fixed alcaline salt.

Volatile alcaline salt.

Potashes.

🝁 Quicklime.

🜕 Saltpetre (nitre.)

Common

⊖ Common salt.
🜖 Vitriol.
○ Alum.
⊖✱ Salt armoniac.
🝐 Borax.
◇ Soap.
🝆 Oil.
🜞 Spirit.
🜈 Spirit of wine.
🜈 Rectified spirit of wine.
🜍 Sulphur.
🜔🜍 Hepar sulphuris.
Phlogiston in general.
☉ Gold.
☽ Silver.
♀ Copper.
♂ Iron.
♄ Lead.
♃ Tin.
X Zinc.
W Bismuth.
♁ Antimony.
♁ Regulus of antimony.
☿ Mercury.
o-o Arsenic.
o=o or Orpiment.
33 or Cinnabar.
ɔ—o Glass.
ɔ—o ♁ Glass of antimony.

Lytharge

o—o ♄ Lytharge; glass of lead.

⊡ Urin.

Powder.

Aquafortis.

Aquaregis.

⊕ Verdigris.

Sublimed mercury.

Precipitated mercury.

MB Balneum maris.

VB Baln. Vaporis.

Sand.

[]. ⊕X Zinc-vitriol (*gallizen stone.*)

C Calx in general.

K Cobalt.

Observations.

It was thought needful to add this explanation of *Chymical Characters*, as it will not only be of general use in the reading of other chymical works, but chiefly in order to understand the following table of *Chymical-solutions*. And since in this table several bodies occur to which no certain characters have yet been given by any of the chymical authors, I have endeavoured to find out some new ones, adapted to the notion of those which are already in use; to some of which I have, for the same reason, joined another figure, which agrees rather better with the idea of the subject.

The following TABLE shews how these different bodies dissolve one another.

TABLE

Observation to the table of Solutions.

Since most chymical operations depend on the various and different solutions of bodies, I have endeavoured to bring them into a table by which they may present themselves to the eye at one sight.

It consists of eight and twenty columns. At the top of each column the figure of that body is always found by which these underneath may be dissolved, so that the figures of all such bodies as may be dissolved by it, are comprehended in the same column. And then I have placed them likewise, as much as it could be done, in such an order, that those which are most difficult to be dissolved by that at the head, are the nearest underneath it, and those which it dissolves the easiest, the remotest from it in the same column; because, by that means, in some columns, the order how they precipitate one another will then appear in the same time. For example; in the fourteenth column, sulphur dissolves cobalt and arsenic the most difficult, after this the mercury, then the regulus of antimony, then bismuth, after this the silver, then the lead, then the tin, and then much readier the copper, but easiest of all the iron. If therefore any one of these mentioned bodies is united with sulphur, it may be divested of its sulphur by one of these bodies which stand under it in the same column.

Explication of the Table

its first division.

Nevertheless this precipitation does not always take place in every column, for two reasons.

1st. Because

1st. Becaufe this diffolving body will either diffolve one of them only in a fmall degree better than the other; or 2dly, becaufe often thefe which fhall be diffolved or precipitated are liable to diffolve one another themfelves; now and then both thefe reafons will occur at the fame time.

So for example, in the twenty-fourth column, iron and copper diffolve one another more difficult than iron and filver, and iron and gold: But fince copper and filver, and copper and gold diffolve likewife one another very readily, the copper cannot be parted from the iron, by means of gold or filver.

its fecond divifion. In the fecond divifion of this table, all thofe bodies are reprefented which cannot at all be diffolved by that at the head of the column, and which in the parting of foffil bodies, will be found very needful and of great affiftance.

In general it muft be confeffed that this table has not yet been brought to that degree of perfection as it were to be wifhed: For it is a matter of great difficulty, chiefly in the dry way, to afcertain the order in which bodies may be diffolved; Whence it muft needs remain liable, here and there, to fome objections. Neverthelefs it will be found much compleater than any that has appeared before of this kind.

End of the First and Theoretical Part of Metallurgic Chymistry.

OF

METALLURGIC CHYMISTRY.

THE

SECOND and PRACTICAL PART.

OF

METALLURGIC CHYMISTRY.

The SECOND and PRACTICAL PART.

PROCESS I.

To obtain a fixed alcaline salt from vegetables.

First Method.

1. BURN any vegetable to ashes.

2. Upon these ashes pour hot water, let it stand for a day and night, then filter it through straw or through a linen bag, as often till the lie is quite clear.

The fixed alcali of vegetables

3. With this lie fill an iron pot or caldron half full, let it boil very softly, adding from time to time as much lie as has evaporated, till at last it begins to condense and to form a saline pellicle on the surface. Then lessen the fire and stir it continually with an iron ladle or wooden stick, till the salt in the form of a dry powder remains, which with a little more stirring, and continuance of heat, may be brought to perfect dryness; and so you have the fixed alcaline salt, which will be of a brownish or yellowish colour.

Observation.

Observation.

Theory

1. The *fixed alcaline salt* being not contained in vegetables originally, but arising only therein during the *incineration*, (§ 227.) they must be burnt to ashes in that manner, and then every kind of vegetable gives an alcaline salt more or less.

burning of vegetables

2. Vegetables contain oils, (§ 227.) the fixed alcaline salt dissolves the oils, (§ 247.) makes a soap, and by that looses its sharpness. The slower therefore this burning of the plants is done, the better can their oily particles unite with the alcaline salt, now generated by the fire, break its sharpness and make partly a kind of soap, and by this means exert different effects in physic. The stronger in contrary the fire is given by that incineration, and the longer a fixed alcaline salt is kept in the fire, the more will the oil be driven out, and consequently the salt be sharper and finer.

But as the fixed alcaline salt dissolves also earths and stones, and vitrifies with them in a very strong fire, the ashes will then partly be turned into glass, if the like strong heat should be given in this operation, hence a less quantity of salt be obtained and therefore some loss suffered, not only with regard to the making of it, but with regard of manuring the soil.

3. Salts

3. Salts being ſoluble in water, but not the earth, and all kind of ſolutions being helped by heat, the *elixivation* of fixed alcaline ſalts ſucceeds beſt with hot water. The light particles of earth ſwimming in the water and rendering it foul, which would mix with and ſpoil the ſalt during the evaporation, are ſeparated by means of *filtering*. With great quantities this operation is performed in the following manner: Elixivation. Filtering

Take a great wooden caſk, upon the bottom of which let a falſe bottom be laid, pierced with many holes, and about five inches diſtant from the bottom of the caſk; make a hole between thoſe two bottoms in the caſk, and faſten a cock into it. Upon the falſe bottom let a quantity of ſtraw be laid pretty cloſe about three inches thick, and upon this have the aſhes thrown in, and then the water let in upon it, which, about eight or twelve hours after, is to be drawn off through the cock. If the lie ſhould not be perfectly clear, (which always happens at firſt) it muſt be filled again into the caſk and let through the aſhes a ſecond time. in the great way.

4. The iron veſſel in which the evaporation is performed, muſt never be quite filled up, becauſe it would not only ſoon boil over, but the ſalt would then during the evaporation collect to the ſides of the veſſel into a hard cruſt which ſticks ſo faſt that it can hardly be taken off. When ſo much water has evaporated that ſome ſmall ſalt grains appear on the ſurface, The boiling.

surface, as if it were covered with a pellicle, the boiling matter must be continually kept stirring, otherwise the salt will settle and stick so fast to the bottom that it requires no less than a chissel and hammer to strike it off, and then even some particles of iron will stick to it, remain among the salt, and render it unfit for many purposes.

How made stronger.

5. If to the ashes, or even to the salt already made, *quicklime* is added, and then the elixivation performed as before, only instead of cold with hot water, the lye will be so strong and pungent, that it dissolves almost every kind of animal substances, most part of vegetables, and among fossils, the sulphur. Likewise the dry salt obtained from such a lie, will be much sharper and fiery than the other made without quicklime.

Second Method.

From tartar.

1. Burn *tartar* to a coal, calcine it then in a slow red-hot fire till most of its blackness is turned white.

2. Throw it while hot in a glass- or stone-vessel filled with clean water, and so soon as all is dissolved, filter it.

3. Evaporate the lie, and calcine the white loose powder which remains, in a crucible.

Observation.

Observation.

1. It makes no difference if the acidous or inflammable spirit, (—♎—♀) and the inflammable fetid oil, (ꝏ♀ *foetidum or empyreumaticum*) is driven out in an open, or in a close vessel; therefore either the coal that remains in the retort after the distillation, or the tartar itself without being distilled, may at once be burnt into such a coal in a crucible.

2. It must be thrown in the water while hot, in order to prevent its attracting the acid and moisture of the air, which it would do in less than two minutes time.

3. This fixed alcaline salt is purer than the former by the first method, and is named (⊖♀) *salt of tartar*. Salt of tartar.

PROCESS II.

To make the fixed alcaline salt from tartar and nitre.

Method.

Take of *tartar* and *nitre* equal parts, when grinded to powder and mixed, put it in an earthen unglassed pot, or in a crucible, and set it over a gentle fire; as soon as the bottom of the vessel Fixed alcali.

O begins

begins to redden, the mixture inflames with a noise, which is called *detonating*, and a whitish alcaline salt remains in the vessel.

Observation.

Nitre inflames with every phlogiston, and consequently likewise with that contained in the tartar. With this detonation the volatile acids as well of the nitre as of the tartar, and even the oily substance of the latter are expelled, and the remainder constitutes an alcaline salt, partly from the saltpetre, partly from the tartar, which, in the art of assaying has the name of *white-flux*, and serves according to (§ 248 till 244.) to dissolve earths and stones so as to make them run into a glass. If to one part of nitre, two, or even three parts of tartar are taken, and proceeded in the same manner as above, an alcaline salt is likewise obtained, but then it retains from the greater quantity of the tartar a considerable part of its phlogiston, whence it is of a black colour, and then called the *black-fluss*. This last answers two purposes at once in the smelting of ores; first as an alcaly, it dissolves the earths and stones; secondly, by its phlogiston, it produces the reduction of destroyed metals into their metalline form.

White fluss.

Black fluss.

PROCESS

PROCESS III.

To obtain a fixed alcaline salt from salt-petre.

Method.

Let the nitre melt in a crucible, and when in fusion, throw some small bits of charcoal successively in, when they are burnt off, repeat the same till you perceive that the charcoal does no more inflame, but remains quiet upon the melted salt. Let either the crucible grow cold as it is, or pour it out into an iron mortar, and you have a fixed alcaline salt of a greenish and whitish colour. Fixed alcali from salt-petre.

Observation.

Though it is true that this fixed alcaline salt arises partly from the coals burnt off with it; yet when considered what a small part of ashes can but arise from those few coals, and how little fixed salt those few ashes could produce; it is not very plain from whence so great a quantity of fixed salt can arise as is obtained by this operation.

This salt is called *fixed nitre*, or *alcalised nitre*.* Fixed nitre.

* The effects of which in this and other various shapes are very peculiar and not to be met with in print.

PROCESS IV.

To obtain the volatile alcaline salt from salt armoniac.

Method.

Volatile alcali.

Take of dry salt armoniac and potashes, equal parts, pound each by itself to a powder, put it in a glass retort, or in a very low cucurbit, pour three or four times as much water into it as the salts weighed, put the vessel in a sand-copple, and distill it over.

Observation.

1. Salt armoniac is a compound of the volatile alcaline salt and of the acid of common salt. To separate therefore the volatile alcaline salt alone from it, a body must be added with which the acid of common salt unites more readily than with the volatile alcaline salt. These are then the fixed alcaline salts as well as alcaline or calcareous earths. Only with that difference, that with the calcareous earth, a salt, not quite so thoroughly dry, will be obtained, as with the fixed alcaline salts.— The reason of it seems to be, that in the fixed alcaline salts originally a vegetable acid, but in the calcareous earths little or no acid is contained. For, the acid of common salt being stronger than the acid of vegetables, this latter is expelled by the former, which then unites with the volatile, now likewise disengaged alcali, and so presents itself in the form of a very light, tender, pure salt-armoniac.

2. A

2. A *volatile alcaline salt* may likewise be made from all kinds of animal particles, such as urine, blood, horn, claws, hair, *&c.* so as likewise from putrified vegetables, and from soot; but they are very apt to retain a part of their empyreumatic oil, whereas the other gives the purest salt armoniac.

PROCESS V.

To make vitriol.

Method.

1. Take an earth or an ore which proves of an astringent taste, pound it to a powder, boil it gently with twice as much clean water in a vessel of glass or of lead, filter the lye, while warm, through a paper moistened with water; pour more water upon the remainder, and let it stand for some days in a gentle warmth, filter it like the former, and repeat the same as often as it yields a vitriolic taste. Vitriol,

2. Let this lye evaporate in a vessel of glass or lead, gently without boiling, 'till you see a pellicle at the surface, like a fine dusty powder. how

3. Bring the vessel in a cool place, and let it remain there twenty-four hours; then pour the liquor off, collect the chrystals which have shot, and put them to dry. made.

Vitriol.

4. The liquor that you have poured off must be diluted with half as much water filtered again through a paper, then evaporated and further proceeded with in the same manner as at No. 2. and 3. 'till no more chrystals will shoot, and the remaining lye or liquor is become a thick oily substance.

Observation.

From pyrite.

1. The ores which will produce vitriol, are commonly the pyrite, whose various kinds, however, prove very different in the yielding of this acid. For, some pyrite loose by themselves their brightness and hardness only by being exposed to the open air, when they will crumble in pieces and turn vitriolic, and in this state they are called *atrament-stone*, (inkstone). This sort of pyrite contains no arsenic. Other sorts of pyrite which, besides their other constituent parts, contain either arsenic, or only sulphur, must first be calcined or roasted, which is done either accidentally in closed vessels when sulphur is made of it, or may be done in an open fire on purpose. Of these roasted pyrite some will not yield vitriol immediately after the roasting, but must first likewise lay for some time in the air: from others immediately after the roasting vitriol may be elixivated, though they will always give more when first exposed to the air. We will endeavour to give some reason for this difference.

Different kinds of pyrite.

The *native vitriol* consists of a vitriolic acid, and of so much copper, iron, or zinc, as it has been able to dissolve. That sort of pyrite which

which gives vitriol, and to which *mispickel* or Vitriol.
arsenical-pyrite is *not* to be reckoned, consists of iron and sulphur, copper and sulphur, or sulphur and arsenic. Sulphur consists of the vitriolic acid and a phlogiston. If therefore vitriol shall arise from a pyritical ore, the phlogiston of sulphur must before be expelled. Now we know by certain experience, that when iron filings and sulphur are mixed, and moistened with water, a motion arises within this mixture, which produces a considerable heat, and lastly pushes out fumes, and even fire, by which then the phlogiston is expelled. If therefore a pyritical ore consists only of iron and sulphur, and is exposed to the air, it will be penetrated with its moisture by degrees, thence grow hot, and consequently its phlogiston be driven out, though slowly. In the same time the vitriolic acid unites with more water, and thence is able to dissolve the iron, and to produce vitriol.

But if such a pyrite contains at the same time copper and arsenic, these being both of a nature to dissolve one another, with the sulphur, they make up a larger compound of mixture, and thence hinder the water from producing the same effect as in the former compound. From hence it appears why this connexion of the copper and the arsenic must first be destroyed by the help of fire; because by this means, besides the arsenic, part of the sulphur will be expelled. Now those pyrite which immemediately after the roasting do not yield vitriol, but must first be exposed to the air, have

Vitriol.

have indeed been deprived of their arsenic, and of some part of sulphur; yet a good part of sulphur remains still in their whole substance; and this is the reason why they must be deprived of their phlogiston by the moisture of the air in the manner as has been said above. This appears clearly from the other sort of pyrite, which will give indeed some vitriol immediately after the roasting, but much more when first exposed to the air. For the vitriolic acid in the sulphur can seldom in part, mostly not at all, be separated from the phlogiston by fire alone; because the sulphur is either driven up in its whole substance, or remains behind united with the fixed body which it has dissolved.

Yet why some kind of pyritical-ores, though they consist only of sulphur and iron, will not crumble in the air, and become vitriolic: this may have its cause partly from its very compact texture, partly from the different proportion of its constituent parts. Lastly, the vitriolic acid contained in the air itself, may contribute something, though not a considerable part to the generation of vitriol.

Why boiled in lead vessels.

2. The acid of vitriol dissolves readily copper and iron. Since therefore some part of this acid is not always quite saturated in the pyrite, the lye of vitriol cannot be boiled in vessels of such metal. And if even this acid were saturated with copper, yet when brought in an iron vessel, the copper would be precipitated by the iron: (See § 252.) Whereas lead

lead is only corroded by this acid; and even then it must be very strong, concentrated, and not diluted with water; consequently this metal is the fittest for such vessels. Vitriol.

3. Hot water dissolves a greater quantity of vitriol than the cold; therefore it discharges as much of it when cold, as it had dissolved above that proportion while warm. Now the surface of the boiling lye being exposed to the air, and consequently cooler than the rest within, the appearing pellicles must needs be the true sign that the water is now as full of vitriol, as it can hold in that degree of heat; because it throws out already the salt at the surface in so small a degree of cool air. Whence it may now be brought to cool, in order that so much of the vitriol as it has dissolved in the heat more than it can hold in its cold state, may separate and collect in the vessel; and this is called *shooting*, and the congealed parts *crystals*. Its shooting in crystals.

4. When a *metal* is dissolved with acids, and this solution evaporated, then crystallised, the obtained crystals are called in general *artificial vitriol*. Artificial vitriol.

PROCESS

Alum.

PROCESS VI.

To obtain alum.

Method.

1. Take of an *alum-ore* (§ 156.) which will make itself known by its sweet nauseous taste, some pounds weight, boil it in a vessel of lead or glass with thrice as much clean water, then filter the lye, pour more fresh water upon the remaining earth, and boil it again; filter that likewise, and do the same as often and as long as the taste proves aluminous. Pour all the filtered lyes into a vessel, and let it either settle for twenty-four hours by itself from its mud, or pass the filter.

2. Evaporate the lye so long, 'till a fresh egg will swim upon it, then let it cool, and set it to shoot into chrystals for twenty-four hours. If some alum has settled at the bottom, which does not often happen, it will be of a dark brown colour, therefore must be cleansed by a repeated solution and crystallisation. But if vitriolic crystals have shoot, they must be taken out and put away. Let the lye which remains after the shooting further be evaporated and crystallised, 'till all the alum is obtained from it.

3. But if no alum has settled, then bring the lye again to boil, and pour the twentieth part of a lye made of pot-ashes into it, or one third part of putrified urine, or as much of dissolved soap-boiler's lye, or some quick-lime. Proceed then with

with boiling 'till some white particles begin to precipitate; then let it settle quietly in a cool place; pour the lye off from those sediments, and proceed then with the making alum as above, 'till at last a thick oily matter remains which gives no more alum. Then take likewise the above sediments, dissolve them in hot water, and cleanse them either by filtering or settling from all foulness, then let it shoot in crystals as before directed. Alum.

Observation.

1. Some have given out that the component earth of alum is a calcareous kind, dissolved by the vitriolic acid; but as from neither of these two substances any alum has been producible by art, it has been said by others, that the foundation of alum must be quite a particular unknown kind of earth. 'Till lately it has appeared, from the greatest probability, that it is an argillaceous earth. For, if oil of vitriol is distilled from a clay, then the remainder elixivated, the lye evaporated, and then crystallised, a salt will be obtained which has all the properties next to alum. Nor does it infer a contradiction that here part of the clay shall dissolve in oil of vitriol, since we have asserted in *Part* I. *Chap.* 2d, *First Division*, that argillaceous earths are insoluble in acids: for it is only in the cold, and even in a moderate heat, that they remain unaffected by acids; whereas in contrary, the calcareous are always affected by them. Besides that this distillation of the oil of vitriol from the clay, is not strictly a solu-

Alum. solution, but only an extraction of some primitive substance of the clay, which breaks and alters the acid spirit of the vitriol, so as to present afterwards another kind of salt resembling the alum.

2. The alcaline salt is added, partly to precipitate the alum, partly to render it pure For when alum is pure, its colour is either white, or somewhat reddish; but if any vitriolic mixture is among it, then its colours turn blueish or greenish. As therefore the vitriolic acid dissolves more readily an alcaline salt than a metal, it unites with that and leaves the metal free, so as to fall to the bottom by itself. Yet this precipitating salt increases in the same time the quantity of alum evidently. For, if such an alum which has been made with urine, is distilled through a retort, with the addition of common salt, a salt armoniac is obtained. However, as the alcaline salts are much more readily dissolved by the vitriolic acid, than the earth contained in the alum, one must take care that not too much of the alcaline salt may be added, and therewith the alum destroyed.

PROCESS VII.

To obtain salt-petre, (nitre).

Method.

Salt-petre 1. Take a nitrous earth, and if it not does contain already a fixed alcaline salt, add to it about one third

third of ashes and quick-lime, pour water to it, let it stand for twelve or more hours, then filter it. Salt-petre

2. Evaporate the filtered lye in a vessel of copper, 'till a drop of it taken out, and brought upon any cold smooth body, congeals; then bring it into a cool place for twenty-four hours, to shoot into crystals. Pour the remaining liquor off from the crystals, dilute it with twice as much clean water, evaporate and crystallise as before, and this so long 'till no more salt-petre will shoot, and the remainder is a thick oily liquor, called *mother-lye*.

3. The salt-petre obtained in these operations must be dissolved again in hot water, with adding a small part of fixed alcaline salt; take away what precipitates, evaporate the lye, and bring it to crystallise according to the method of No. 2. then a purer salt-petre is obtained. How refined.

Observation.

1. That a fixed alcaline salt makes up a great part of the salt-petre itself, appears from the third process; so as likewise from the regeneration of salt-petre from its own spirit when combined with a fixed alcaline salt. And this is the reason why a fixed alcaline salt must be added to the nitrous earth, if it is not contained already therein. Besides this, the fixed alcali serves to separate the superfluous calcareous earth which had dissolved therein by the nitrous spirit, because the acid salts dissolve more readily an alcaline salt than a calcareous earth. And that there is such a calcareous earth contained in the lyes of salt-

Salt-petre. salt-petre, is apparent by the white magnese which is always obtained from the *mother-lye*, when reduced to dryness, burnt in a red-hot fire, elixivated again, and then calcined into that white earth which has the name of *magnese*; and that both the nitrous spirit and the spirit of common salt are contained in that mother-lye, is made apparent by dropping some oil of vitriol into it, then distilling that liquor out of a retort, when the product will be an *aqua-regis*.

Magnese.

2. By a repeated solution and crystallisation. the salt-petre is deprived of its admixture of common salt, and consequently rendered purer; because the common salt dissolves almost as readily in the cold as in the hot water; whereas the salt-petre requires a hot water, and dissolves much less in the cold. When therefore the lye which contains both the salt-petre and the common salt in a dissolved state, is grown cold, it dismisses as much of the salt-petre as it only could retain when hot, which now, when cold, collects and shoots in crystals; whereas the common salt remains for the most part still dissolved in the cold liquor; and this is likewise the reason why crystals of the first shooting are always the best, and purer than those of the second and following shootings.

PROCESS

Common salt.

PROCESS VIII.

To make common ſalt.

Method.

Let the ſalt water (which is called *ſoda*) boil ſo long 'till a pellicle of ſmall cryſtals like a white duſt, appears on the ſurface; then leſſen the heat, that the *ſoda* may no more boil, but only ſimmer, and thoſe ſmall cryſtals ſwimming on the ſurface will grow larger, and by their own weight ſink to the bottom. When as many cryſtals have ſettled as to reach nearly to the ſurface, then let the liquor be poured out, of which you may afterwards, in the ſame manner, obtain the remaining ſalt. Soda.

Obſervation.

1. Since almoſt the ſame quantity of common ſalt will diſſolve in cold water as in the hot, this ſalt cannot be obtained out of the ſoda by means of cryſtalliſing, as with other ſalts; but that end muſt be obtained by depriving it it of its water, ſo much as to be nearly in a dry ſtate. Theſe cryſtals, when collected at the bottom, conſiſt of ſmall cubes, this being the form peculiar to this ſalt; oftentimes they repreſent the trunk of a pyramid, and are hollow, and open at their baſis.

2. When the cryſtals begin to appear on the ſurface, the heat muſt be leſſened; becauſe by a continuance of the ſame degree, the whole

Common salt

whole surface would be covered with a thick crust of salt; and then an evaporation of so gentle and slow a kind as here required, be entirely obstructed.

3. Some *sodas* being poor, that is, containing but a small quantity of salt, they would require great expence, and a long time of boiling in so great quantities. To that purpose, a method has been found out to condense such *sodas*, that is, to thicken the liquor by depriving it of part of its water before it is brought to boil. This method is called *graduation*, and is done in the following manner:

Graduating.

A long and high building is erected, left open on all sides, in order to give a free draught to the air; then several stratas of straw, fagots, or thorns, are made and laid at proper distances, nearly in a horizontal direction; then the soda is raised up by pumps to the upper stratum, from which it drains in small drops down upon the next stratum underneath, and from that again to the next below; and so on, 'till to the bottom. Since then air and water dissolve one another; (See the Theoretical Part, Chap. 2d. Div. II.) and the smaller the drops grow, the more their surface is exposed to the air; it follows, that by this division of the soda into small drops, and exposing their surface variously to the air by their falling down from place to place, a great part of the water must be dissolved by the air, and consequently the *soda* condensed and

Gradier-house.

and made richer of falt in proportion to the bulk of water it contained before. Common falt.

4. Sometimes this operation is entirely left to natûre, when in fome countries the fea-water collects upon dry land, where merely by the heat of the fun it evaporates and leaves the falt in its dry form behind. At other places the fame operation is affifted by art, viz. by leading the falt-water of the open fea into large level ditches, where it is likewife evaporated by the fun and air.

PROCESS IX.

To obtain the acid of vitriol.

Method.

1. Take fix or eight pounds weight of green vitriol, lay it in the fummer time in the fun, and at other times upon a warm furnace, and it will crumble into a whitifh powder. Or put it in an unglafed earthen or iron veffel, give fucceffively fire 'till the vitriol begins to boil and to fmoke: increafe the fire gently, and the vitriol will become a thick afh-grey fubftance, and then it muft be continually ftirred, elfe it would bake into a hard lump; and from thence the fire muft be gradually leffened; 'till it is reduced into a dry powder. Acid of vitriol. Its calcination.

Acid of vitriol.

2. With this calcined vitriol fill an earthen or a luted glass retort half full, order it in a reverberating furnace, wall the furnace round the neck of the retort up with some loam and brick, apply a joiner to the neck of the retort, and the end of the joiner, having first some wetted linen wound round it, introduce into the mouth of a large glass receiver about two inches deep, lute the chinks with linen rags and a good paste, and let it stand to dry.

How distilled.

3. Then give a gentle fire, so that the retort may only grow warm; increase it every quarter hour, by small degrees 'till all is quite hot, and an aquatic vapour will rise over. This degree of heat being given for six or eight hours, increase the fire 'till you see white vapours rise over in the receiver. This heat must be continued about twelve or eighteen hours, 'till the oil begins to run down the sides within the receiver: then increase the fire so much that the retort may be quite red-hot, for the space of twelve hours without intermission.

If the spirits should penetrate through the paste, lay the slits over with fresh rags and paste when first made warm. After the fire has been continued the time above directed, let it go out, and all remain unmoved 'till the receiver is quite cold.

4. Then moisten the paste with wetted rags and draw the receiver gently off straightways, to avoid its breaking, and any thing falling into it; pour the liquor through a funnel into a glass vessel, and avoid every where the fumes and vapours, which are very hurtful to the lungs.

Obser-

Observation.

1. By the calcining of the vitriol most part of these aquatic parts are expelled, which would not only retard the operation, but make the receivers fly in pieces by the impetuosity and multitude of these elastic vapours. Acid of vitriol.

Another reason of this calcination may be this: the iron cannot be dissolved by the vitriolic acid without a sufficient admixture of water; therefore when this water has been for the most part expelled by calcination, the oil can no more keep the iron in a dissolved state, and consequently be no more bound up and fixed by that metal; but being for the most part disengaged, it may now be brought, by the force of heat, to rise over in the receiver. Copper, in contrary, cannot be dissolved by the oil of vitriol, unless when concentrated and freed from water, and therefore copper-vitriol does not part with its acid so readily as the iron vitriol. If the vitriol has been calcined to redness, the receiver may be of a much lesser size; because then neither any water, nor much of the spirit will be obtained, but only the oil alone, the former having been driven out by the strong calcination.

2. The acid of vitriol being the strongest in nature, it may not be separated from its metalline parts, with which it is so strongly united, but by fire; and this renders the separation not only difficult, but never to be effected completely.——For, if the fire should be continued a much longer time

Acid of vitriol.

than above directed, there would still more vapours rise over; and yet out of the remainder, which is called *colcothar*, and is of a red colour, a yellowish vitriol may be obtained when elixivated.*

3. If the receiver should burst by driving the elastic vapours too quickly over, one may run the risk of being suffocated, or at least very much hurt by their pernicious fumes. For that reason it is very useful to leave but the smallest aperture in the lute where the receiver is fastened to the joiner, which may be opened and stopped by turns with a small glass or wooden stopper, giving vent to the vapours and spirits at some intervals.

Its spirit.

Its oil.

4. One part of the acid, which goes over in white vapours, is very volatile, and called *spirit of vitriol*; but the other part, which is pretty fixed, comes over in drops, and is called the *oil of vitriol.* If therefore the receiver has not been changed before the rising of the oil, the spirit may afterwards be separated from the oil, by putting it in an alembic, upon which a helmet is to be luted; then a fire of the 50-thousand degree of Farenheit's thermometer given, by which the spirit will rise up in the helmet, and from thence in the receiver without any of the oil.

* The reason of this is the same as mentioned at No. 1. viz. that a great part of the vitriolic acid is bound up and fixed by the iron.

But

But if a joiner with a tubula has been applied at first in this operation, and a small receiver applied to the tubula, then the aquatic vapours, as being the first which came over, will go in this small receiver, and the spirits in the great receiver. When the oil begins to come, the great receiver must be taken off, and another applied at its place, and by that means the oil and spirit may be obtained separately in the same operation. Acid of vitriol.

5. *Oil of vitriol* may likewise be obtained from *alum* by the same method; the alum must first be calcined, yet the acid is still more bound up in that mineral than it is in the vitriol, whence it yields by far less of the oil. It is called the *spirit of alum*, and the remainder, *burnt* or *calcined alum*. Spirit of alum. Calcined alum.

6. Sulphur contains the acid of vitriol in every respect equally with the vitriol, and may be obtained by burning only the sulphur under a moistened campana of glass, or even under a wetted linen bag, when it collects all in the campana or in the bag; from which latter it may be quenched out along with the water, and afterwards separated by distilling the water off, and then it hath the name of *spirit* or *oil of sulphur*. Oil of sulphur.

PROCESS X.

To obtain the acid of ſalt-petre or nitre.

Firſt Method.

Spirit or acid of nitre.

Grind three parts (18 oz.) of the pureſt ſalt-petre to a fine powder, put it in a glaſs retort or in an alembic; pour one-third (6 oz.) of oil of vitriol into it, put the retort inſtantly in a ſand coppel, and faſten a large receiver to it, (both which muſt be ready at hand) lute the joints with a paſte made of quicklime, clay, and ſome ſand. The matter will inſtantly grow warm by itſelf, and emit red vapours. Then make a gentle fire under the ſand-coppel, and the receiver will be filled with red damps, when the ſpirit comes in the ſame time over in drops. Increaſe the fire by degrees as much as can be given to a ſand-heat. Then let the fire go out, take off the receiver ſo ſoon as the neck of the retort is cooliſh, pour the ſpirit in a glaſs with a grinded ſtopper, which you muſt do under a chimney or in the open air, to avoid the red fumes, as being very hurtful to the lungs.

Obſervation.

1. The *vitriolic acid* is ſtronger than that of *nitre*; and as the acid of this was bound up by the alcaline part of the nitre itſelf, the vitriolic, as the ſtronger, takes inſtantly hold of that alcali, and renders therewith the nitrous acid free and volatile, ſo that then it can be raiſed and driven out by the fire:—for even during the mixing, the nitrous ſpirit begins already

to

to preſent itſelf in red fumes, for which reaſon the receiver muſt be immediately applied. Sometimes they will penetrate the chinks of the paſte during the diſtillation, when they are to be diſcovered either by their red fumes, or with holding a lighted coal to the chinks; for then a bright light will appear upon the coal, which reduces it almoſt inſtantly into aſhes. This therefore being perceived, other linen rags with freſh paſte muſt be laid on, elſe part of the ſpirits would be loſt. Acid ſpirit of nitre

2. The *ſalt-petre* may as well be diſſolved only in water, then this lye mixed with a fourth part of oil of vitriol, and this being put in the retort, the water diſtilled of by giving firſt a gentle heat, which will make the water riſe over by itſelf; then another receiver being applied, and the fire increaſed, the nitrous ſpirit is likewiſe obtained by itſelf. The remainder in the retort is a new compound, made up of the vitriolic acid, and the alcaline part of the nitre, conſequently a *tartarus vitriolatus.* Tartarus vitriolatus.

Second Method.

Grind calcined vitriol (ſee Proceſs IX.) into a fine powder; do the ſame with the like quantity of nitre, then mix both together, and put the mixture in an iron or glaſs retort, (when of glaſs, it muſt be luted); order it in an open fire, which muſt be increaſed by degrees 'till the veſſel grows nearly red-hot. This degree muſt be continued for ſome hours,

hours, then let the fire go out; and when the receiver is pretty cool, the spirit of nitre to be brought in a phial with a ground glass stopper.

Observation.

Acid spirit of nitre

1. Although the acid of vitriol has not been added in this process in its separated state, but with all its irony substance, yet its connexion with the iron is in a great measure broke by the previous calcination. Since therefore an acid unites more readily with the fixed alcaline salt than with a metal; and as the vitriolic acid is stronger than that of the nitre, the former leaves the iron by the assistance of fire, takes hold of the alcaline part of the salt-petre, and frees therewith the nitrous acid, so as to rise and to go over into the receiver.

Is not pure.

Called aquafortis.

How to obtain the pure spirit of nitre

2. This *nitrous acid* is however, seldom quite pure, but mostly tinged with the vitriolic, as well as with the acid of common salt; whence from the use it is commonly made of, it has the name of *aquafortis*. But if you desire to have the *nitrous acid pure*, take one part of salt-petre, four of bolus, or clay, loam, or brick-dust; dissolve the salt-petre in water, inspissate the above earthy matter with this lye, let it dry, put it in a retort, apply a receiver, and distill in an open fire; and then this acid is called particularly *spirit of nitre*.

3. Some add sand, alum, quick-lime, hæmitates, (blood-stone) and various other ingredients, which

which they do partly to hinder the fluxing of the nitre and its foaming up, partly from ignorance; because it makes not only a needless heap of mixtures, and renders the operation dangerous, but the spirit of nitre is thereby adulterated and produces much less in quantity than it should.*

PROCESS XI.

To obtain the acid of common salt.

Method.

Put three parts of common salt in a retort, and pour one part of oil of vitriol into it, and there will instantly raise up a white suffocating vapour; apply therefore immediately a receiver, lute the joints, and give in a sand-bath, for the space of three or four hours, only a gentle heat; for the elastic spirits will rise with great impetuosity, and penetrate even sometimes the lute with a hissing noise; increase therefore the fire afterwards by degrees 'till the sand-coppel is red-hot; then let the fire go out, and the neck of the retort being cooled, take off the receiver, and you have a *fuming acid spirit.* This, when distilled again through an alembic, in a gentle heat, the fuming spirit will rise over alone, and the acid remain behind in a yellow-greenish liquor.

Acid or spirit of com. salt.

* Yet it may be questioned if a clean sand would not adulterate it less than brick-dust, clay, or loam.

Or,

Acid of salt.

Or, dissolve the salt first in water, and drop the oil of vitriol into it gently and successively, else the retort would grow so hot as to burst. Distill first with a gentle heat in a sand-coppel, and the water will come first; increase then the heat gently 'till you see the spirits rise over in winding serpentine stryas: then a strong fire may be given without danger. This spirit of salt gives none of these fuming, suffocating fumes.

Observation.

1. The *acid of salt-petre* is stronger than that of *common salt*, but the *vitriolic acid* being stronger than both, its effects are here the same as in the preceding process with the nitre; for, it unites with the alcaline part of the common salt, and makes therewith its acid free, that it can rise and go over in the receiver by itself.

2. The volatile fuming spirit obtained at No. 1. is here rendered more fixed by the addition of water; which being a more dense body, is able to lessen that great volatility of the spirit. If therefore that fuming spirit has been made already, its great volatility may instantly be fixed by the addition of a little water; or by dissolving the salt in water before the distillation, as before directed.

3. This spirit of salt may, as well as that of nitre, be made after the preceding process, shewn in the *second method*, with the crude cal-

calcined vitriol, only that it requires a ſtronger and longer fire. **Acid of ſalt.**

4. Again, the acid of common ſalt may be obtained, by mixing one part of ſalt with three to four parts of bolus, then diſtilled through the retort in an open fire. But then the ſalt muſt firſt receive a preparation, which is thus made:—Put the ſalt in an earthen unglazed pot, and cover it; give it a gentle fire, and increaſe it no farther than to make the pot grow half red hot, then the ſalt will make a crackling noiſe, and when taken out be very white, and cracked into very ſmall grains, and have loſt near a fourth part of its weight. This operation is called *decrepitation*. And if this preparation has been omitted, it will fly about in the retort, and even into the receiver, and ſometimes break the veſſel. **Decrepitation.**

5. The remainder in the retort being elixivated with hot water, evaporated and cryſtalliſed, a ſalt will be obtained, which conſiſts of the acid of vitriol and the alcaline part of the common ſalt, and is called *Glauber's ſalt*. **Glauber's ſalt.**

PROCESS XII.

To make aquaregis.

Firſt Method.

Take one part of common ſalt when before made perfectly dry, grind it to a fine powder, and put **Aqua-regis.**

put it in a glass retort; pour two parts of the best aquafortis to it, distil in the sand coppel first gently, but when all the liquor is gone over, give to the remainder the strongest fire that can be given in a sand-heat.

Second Method. Without distilling.

Pour a fourth part of the acid of common salt into aquafortis; or dissolve a fourth part of salt-armoniac in aquafortis, (§ 223.) and it will colour the aquafortis yellow, and raise a quantity of white vapours, wherefore it must be done under a chimney, and without stopping the phial more than with a paper, else it will either burst, or force the cork to fly out with violence, and then the best part of the spirit be thrown out along with it.

PROCESS XIII.

To dissolve calcareous stones with fixed alcaline salt.

Method.

Calcareous earths and stones

Grind one part of *chalk* to a fine powder, and mix it with as much dry, pure, fixed alcaline salt; fill with this mixture an earthen pot or crucible, which will bear a strong fire, two-thirds up, cover it, and put it in a draught or glass-furnace, and let it be given a strong fire for some hours; and you will have a hard glass of a yellowish colour.

Obser-

Observation.

1. If the operation is performed in a glass-furnace, you may have a little aperture left or made at the egde of the crucible, in order to introduce an iron rod, and to try now and then the mixture if it is melted clear. But in such furnaces the pot should never be brought at once into the strongest fire, but first be left for an hour in the fourth chamber, in order to have the mixture first in a manner roasted or calcined, and likewise the pot sealed. Calcareous earths

2. A pot must never be quite filled up with a mixture which shall be vitrified; because the matter will always foam up during the solution, and consequently run over.

3. Two parts of fixed alcaline salt, and one part of chalk, make a pretty hard, greenish yellow glass, But one part of the salt only, with two parts of chalk, do not vitrify, but will only bake together in a very hard substance.

PROCESS XIV.

To dissolve argillaceous stones with fixed alcaline salt.

Method.

Take one part of pure white clay, and two parts of fixed alcaline salt; proceed as in the above process, and you will have a yellowish glass. Argillaceous.

Obser-

Observation.

Argillaceous stones require more of the fixed alcaline salt to their solution, than the *calcareous*; therefore equal parts of clay and alcaly do not flux in the same degree of fire, but bake only fast together.

PROCESS XV.

To dissolve gypseous stones with the fixed alcaline salt.

Method.

Take of each the same quantity, and proceed as before.

Observation.

Gypseous stones. Equal parts of gypseous stones and of the alcaline salt, make a hard, white opake glass. If two parts of plaster and one part of alcali, the glass is of the same colour, but somewhat harder, and appears to have foamed up during the fusion.

PROCESS XVI.

To dissolve glassy or vitrescent stones with the fixed alcaline salt.

Method.

Take a white sand or any stones of the vitrescent order, make them red-hot in a strong fire, throw them in cold water whilst in full heat, then grind them in a mortar to a fine powder. Take of this powder one part, and two parts of fixed alcaline salt, and proceed after the same method as given in Process XIII. Vitrescent stones

Observation.

1. The new body obtained with this composition, is the same as *common glass*. But in the great way, a less quantity of the salt is commonly added, because they give not only a greater and much longer heat, but use some other mixtures besides the salt, which quickens the fusion of the sand. For in a very strong and long continued heat, even four parts of the stony matter with one part of the salt will come in fusion. The greater the proportion of stone is to the salt, the harder is the glass.

2. The purer the salt and stones are, the finer and clearer will be the glass. The black flints and other sorts which will turn white when calcined, make as good and hard a crystal glass, as if rock-crystal had been taken in

in their place. But as with the pounding and grinding ſome irony particles may be introduced among the powder, which muſt render the glaſs worſe in colour and tranſparency, it is proper to pour ſome weak aquafortis upon that powder, which when left for ſome hours upon it, and ſtirred ſometimes about, then poured off, and the powder edulcorated with clean water, this inconveniency is prevented.

3. Three parts of the white opake quarz with one part of the alcaline ſalt, make a hard milk-white glaſs. One part of that quarz, with three of the alcali, makes a greeniſh, ſemi-pellucid glaſs.

4. Three parts of *(fluſs) glaſs-ſpar* with one part of fixed alcaline ſalt, produces a dark blackiſh hard glaſs which ſtrikes fire; though the ſpar did not do the ſame before by itſelf. With the reverſe of this proportion it makes a quite black glaſs.

PROCESS XVII.

To diſſolve all ſtone kinds contained in the Table, § 246. (*page* 118) one with another, without any flux.

Solution of ſtones by themſelves.

Method.

1. Mix one part of *chalk* with three parts of *clay*. Or one part of *chalk* with five parts of *clay*.

2. Mix

2. Mix half a part of *plaster* with one part of *clay*; or five parts *plaster* with six parts *clay*.

3. Mix two parts *clay* with one part of (*fluss-spar*) *glass-spar*; or one part of *clay* with two parts of *glass-spar*.

4. Mix two parts of *plaster* with one part of *glass-spar*; or one part of *plaster* with two parts of *glass-spar*; or of each equal parts.

5. Mix two parts of *chalk* with one part of *glass-spar*; or four parts of *chalk* with one part of *glass-spar*; or vice versa.

Put each mixture in a good crucible, and a cover on it, and give for some hours the strongest fire in a draught furnace.

Observation.

1. The hardness, colour, and transparency of the glass produced by these mixtures, will be different according to the different stone sorts and proportion employed. So for example, *four* parts of *glass spar* with *one* part of *chalk*; and likewise *one* part of *glass-spar* with *four* parts of *chalk*, will both be fusible; but the former much more so than the latter. In contrary, *two* parts of *chalk* and *one* part of *glass-spar*, will prove very refractory. Five parts of plaster and six parts of clay make a beautiful transparent chrysolite-coloured glass, which strikes fire.

2. The mixtures of No. 5, are so fusible as to eat often through the crucible. The white opake-quarz is indeed a fusible vitrescent stone, and melts by observing the just proportion, even with all those stone sorts, which the other transparent quarz and sand will not melt with, yet the glass-spar still exceeds it, and the more of it is added to the mixture the more it becomes fusible; though some limits must be observed.

3. It is very remarkable that two different stone-sorts will dissolve one another and vitrify, which when each is taken alone, will never come in fusion nor melt into glass. This circumstance proves of very great utility in the business of smelting, and has since been partly experienced with advantage, when for example, glass-spar, and by the iron-works, calcareous stones have been added, to promote the intended fusion, though only by way of tradition or custom, without knowing the true principle and reason. From hence we may discover that ashes and coals and the fixed alcaly contained therein, becomes not so absolutely necessary for fluxing the stony particles of ores: and that consequently the first melting of ores, called *rough-melting*, wherein no phlogiston is required to the reduction of metals, might be performed without the expence of charcoals, only with other sorts of fuel, such as pit-coal, if the furnaces, manipulation, and labour were properly adapted for that purpose.

PROCESS

PROCESS XVIII.

To dissolve two stone-sorts, which do not dissolve one another, (*see the table* § 246.) by means of a third stone-kind.

Method.

Solution of two stone-kinds by a third.

1. Mix three parts of *chalk*, three parts of *clay*, and one part of *sand* together.

2. Mix one part of *chalk*, five parts of *clay*, and one part of *sand* together.

3. Mix of *chalk*, *clay*, and *sand*, each equal parts together.

4. Mix half a part of *plaster*, one part of *clay*, and one part of *sand* together.

5. Mix five parts of *plaster*, six parts of *clay*, and two parts of *sand* together.

6. Mix two parts of *clay*, one part of *plaster*, and one part of *chalk*, together.

7. Mix one part of *chalk*, four parts of *glass-spar*, and half a part of *sand*, together.

8. Mix one part of *clay*, four parts *glass-spar*, and one part of *sand* together.

9. Mix one part of *plaster*, one part of *glass-spar*, and one part of *sand* together.

Q 2 Put

Put each of those mixtures into a good crucible, cover it, and set it upon a brick, or better, upon a foot made on purpose of a good clay, and if you put several crucibles in the furnace at once, fasten them with a piece of clay together at the bottom as well as above with their covers, in order to secure them from falling down, lay this foot or brick upon another brick which you have placed upon the grate in the furnace, fill the furnace up with dry charcoal, and put some lighted coals at the top; by that means the fire will lighten from above by degrees; and when lighted, increase the fire, and give it for two or three hours as strong as it can be.

Observation.

1. When two stone-sorts which do not dissolve one another, shall be dissolved by a third stone-kind, this must be such a one as will either dissolve one of the two or both. (§ 246.) Of the last kind is the mixtre of No. 6, of the first are all the rest.

2. Those experiences, will like the former, prove of very great utility in the art of smelting, if applied with judgment. For, in the great smelting houses it is customary to add as much of scorias to the refractory ores as their own quantity, in order to bring these ores to fuse. Yet since in these smelting houses, where so different ores are brought together in great quantity, various stone-sorts occur, it is obvious that if a proper respect would be had towards their reciproque solutions by ordering and

and disposing these ores after the same principle, a great deal of labour, coal, and other expences might be saved. Again, at some places the melting is entirely left off, and this, as they say, for want of ingredients, whence great loss and expence is caused either by carrying the ores a great distance to another smelting house, or the ores lay by useless. Yet there is no doubt but by these experiences some improvements may be made to advantage in this great business. Some experiments in the small way have fully proved this opinion to be practicable.

3. From hence we may likewise learn that it is better to bring various kind of ores from several mines to one smelting house, then if every mine would keep its own smelting house, because not every kind of stone which may serve for dissolving the other will be found at the same mine. Lastly, many other circumstances may occur to be noticed with regard to the colour, transparency, hardness, fusibility, and refractory nature of these bodies.

PROCESS XIX.

To dissolve every stone kind with borax.

Method.

Make a mixture of the following species, viz.

Solution with borax

1. To one part of *borax*, two parts of *chalk*.

2. Of *borax* and *chalk* each equal parts.

3. To two parts of *borax*, one part of *chalk*.

4. To one part of *borax*, one part of *plaster*. (*gypsum*.)

5. Of *borax* and *plaster* each the same quantity.

6. To two parts of *borax*, one part of *plaster*

7. Of *borax* and *clay* each equal parts.

8. To one part of *borax*, two parts of *clay*.

9. To one part of *borax*, two parts of *sand*.

10. Of *borax* and *sand* equal parts.

11. To two parts of *borax*, one part of *sand*.

12. To one part of *borax*, two parts of *glass-spar*.

13. Of *borax* and *glass-spar* equal parts.

14. Of *borax* and *white opake-quarz* equal parts.

Proceed with each of these mixtures as in the former Processes. Yet the fire must not be given in so strong a degree.

Observation.

Observation.

1. *Borax* foams up in the fire like a scum, and so does every mixture of vitrifying substances during its solution in the fire, by which they frequently happen to run over; but when the borax has before been calcined, this inconveniency is for the most part prevented. This preparation of the borax is performed in the following manner. Grind the borax to a powder, fill a crucible no more than the fifth part with it, and give it so gentle a heat that the crucible may hardly begin to redden, and the borax will first come in fusion and boil like pitch with a crackling noise, then it rises up in a very loose white scum, till to the border of the pot, and in that state it must be taken out when it may be rubbed to a powder between the fingers; if it remains longer in the fire and grows too hot it soon melts into a glass and then sticks to the sides of the crucible, whence it must be scraped out and grinded again to powder. How to calcine the borax

2. Upon this principle depends the utility of borax to promote the fluxing of such metals which require a great heat to their fusion, such as gold, silver, &c. and the use of soldering. (See § 260.)

3. If to one part of borax and two parts of refractory vitrescent stones some fixed alcaline salt or fixed nitre is added, it makes a perfectly clear and hard glass. This is therefore the

artificial diamonds

the proper mixture for making thoſe various tranſparent, hard, and coloured glaſſes, which are called *artificial precious ſtones.*

PROCESS XX.

To diſſolve every ſtone kind with lytharge.

Solution with lytharge or minium.

Method.

Make an exact mixture,

1. Of one part of *chalk* with two parts of *minium.* (Red-lead.)

2. Of two parts of *chalk* with two parts of *minium.*

3. Of one part of *plaſter* with one part of *minium.*

4. Of one part of *plaſter* with two parts of *minium.*

5. Of one part of *clay* with two parts of *minium.*

6. Of *clay* and *minium* equal parts.

7. Of one part of *ſand* with two parts of *minium.*

8. Of one part of *ſand* with three parts of *minium.*

9. Of

9. Of one part of *glass-spar* with two parts of *minium.*

10. Of one part of *white opake-quarz* with two parts of *minium.*

Proceed as in the foregoing Process, either in a glass or draught-furnace.

Observation.

From these experiments appears partly the use of *lead* in the assaying of ores upon gold and silver. For, upon mixing these ores with granulated lead, this metal will in a strong fire turn successively into a lytharge, which then dissolves the stony particles of the ore, and vitrifies with them into a glassy very fusible scoria, out of which the particles of gold or silver, may easily sink down and unite with the remaining lead in fusion at the bottom whence it is brought upon the coppel or test: And so is likewise this separation upon the test grounded nearly upon the same reason. For, by the strength of fire the lead is there reduced into a soft lytharge, which enters into the pores of the test, dissolves partly the dust of the ashes, and leaves the silver and gold together by themselves behind, perfectly pure without any other admixture.

1. Every *calx* of *lead*, such as lytharge and white lead, will indeed produce the same effect of dissolving these stone kinds; but the

but the minium is commonly made use of in these operations, because it has already suffered a long continued fire, and because the lead is not so easily reduced into its metalline form by fire alone from this, then it is from the lytharge and white-lead, chiefly from the lytharge; for, by such a too quick reduction, the experiment with respect to the proportion between the parts, which shall be dissolved and those which dissolve the other, would be rendered false.

2. It is very remarkable that chalk, clay, and plaster, are capable to reduce part of the minium into lead, which none of the vitrescent-stones do, whence these latter will serve better to the making of *glass of lead*, than the former.

3. The more of these stones are added to the calces of lead and reduced therewith to glass in a strong fire, the harder and compacter will be the glasses made of the mixture, so that they may even strike fire.

4. From hence it may be understood, why earthen vessels, by melting lead, and calces of lead, and chiefly such lytharge which has not been quite saturated, are so easily penetrated, or at least much corroded by these substances when kept for a long time in the fire. This inconveniency may in some measure be prevented by making those melting-pots in a mold and compressing the clay closely

together

together therein; for then the lead or lytharge does not find so many pores, which it may penetrate, dissolve the terrestreous particles, reduce them into glass, and make its way through it.

PROCESS XXI.

To dissolve stones with the calx of antimony.

Method.

1. Grind the *crude antimony* to a fine powder, put it in an earthen flat vessel, set it over a very gentle fire, which you must do either under a chimney of a very good draught, or in the open air, and it soon will begin to fume; stir it continually with an iron hook, increase the fire very gently, and go on with stirring the matter till no more fumes appear, and then it will be reduced into a grey calx. If the fire during this operation should grow too hot, the antimony will soon bake together in lumps, and then it must be immediately taken off and grinded again. This operation requires some hours time. **Solution with calx of antimony**

2. Take of this calx two parts, mix it with one part of any of the four genera of stones, and bring the mixture in a covered crucible to melt for some hours in a strong fire.

Observation.

By this calx, chalk is reduced into a grey, shining, opake glass, but the sand into a yellowish glass. Plaster proves with this calx in the same degree of fire, much more refractory, and comes but partly in fusion, representing a pale yellowish glass. Clay will not at all flux with it in this degree of fire, but bakes only into a hard matter.

PROCESS XXII.

To dissolve oil with a fixed alcaline salt and to make soap of it.

Method.

Soap. 1. Put in a bold head of glass, of the liquified oil of tartar and of olive oil each the same quantity, unite it together with shaking, and it will turn into a white, thick, opake mixture. If this mixture is afterwards left quiet for a while, it separates again, and the olive oil will swim uppermost.

2. Boil this mixture over a gentle heat, till the humid part is evaporated, and then a white, thick substance remains, which yields an oily nauseous smell, and a sharp alcaline greasy taste, and will liquify in the air.

But

But if during the boiling, either fo much of the fixed alcaline falt, or as much of oil is added, as is required to keep it from liquifying in the air, and to diffolve perfectly in water without leaving any figns of the oil therein, nor yielding an alcaline tafte upon the tongue, then it is a perfect foap.

Obfervation.

1. This folution appears to proceed moftly from the acid contained in the oil, becaufe fuch oils in which this acid is not difcovered, unite with much more difficulty with the alcaly.

2. The fame folution has been obferved to fucceed the better, the ftonger the alcaly is: Since therefore this falt may be made much ftronger by the adding of quicklime, and as likewife a proper quantity of water helps greatly to this folution during the boiling; the foap-boilers make firft a ftrong lie of afhes and quicklime fo that an egg may fwim upon it, and then another weaker fort is made, in which the egg will fink. With this weak lie they mix firft the oil in equal quantity, then boil it over a gentle fire till the water is moftly evaporated, and then they add thrice as much of the ftrong lye as the quantity of oil was at firft, and therewith they go on with boiling 'till a drop of it when brought upon any folid body, congeals inftantly into a foap. They have then another art to feparate the foap from the remaining liquor, which is, to throw a certain quantity of common falt into it, when the water uniting much more readily with

with the salt, leaves the soap swimming by itself on the surface.

3. They use likewise the oil and fat of fishes and of other annimals in the place of vegetable oils; but the purer the fixed alcaline salt and the oil is, the finer will be the soap: therefore train-oil makes but a coarse black soap.

PROCESS XXIII.

To dissolve vinegar with fixed alcaline salt, and to make therewith a regenerated tartar.

Method.

1. Pour into an alembic having a narrow neck, upon a quite pure fixed alcaline salt, as much of strong vinegar, as just to cover the salt entirely: shake the mixture for a good while together, and you will perceive a gentle ebullition, which however ceases soon again. Pour then some more distilled vinegar into it, shake it as before, and the ebullition will be somewhat stronger. Repeat this with adding small quantities of vinegar, till no more ebulition is perceived, which will be with about fourteen times the quantity of vinegar to the weight of the alcaly. The last adding of the vinegar must be done with small quantities by often shaking the glass gently and observing very closely if any ebullition appears. Then the vessel must be left unmoved in a warm place for four and twenty

twenty hours; after which a ſmall portion of vinegar is again added with ſhaking the glaſs. If then no more ebullition is perceived, it proves that the *point of ſaturation* has been found. This mixture diſcovers none of the pungent taſte of the alcali nor of that of the acid, but leaves only a ſaltiſh ſenſation upon the tongue.

2. Filter this volatile mixture and diſtill it through a ſtill-head, and what comes over is but a pure ſingle water, but the remainder in the cucurbit turns ſucceſſively yellow, blackiſh, and at laſt quite black, greaſy and thick, and is of a very penetrating taſte; take ſome of that matter and obſerve if it will ſtill make an ebullition with vinegar; if it does, try to find the point of ſaturation again.

3. When the true point of ſaturation is found, pour the liquor off from the ſediments, and drive all the watery particles off, and a black-reddiſh, ſaline matter remains behind, which is of a very ſingular, ſaponaceous taſte, and is called *regenerated tartar*. If the fire is given too ſtrong to this matter it grows volatile and diſſapates entirely.

Obſervation.

This ſoapy ſubſtance when at laſt inſpiſſated by a very gentle heat, turns when cold into a curious foliated form like a ſelenite; when warm it liquifies again into a fat oil, and re-aſſumes its foliated form again in the cold: hence

hence it has the name of *terra foliata tartari.* But if by inspissating this matter, the heat is given in the least degree too much, it immediately flies off.

When brought in a retort, and a strong fire is given, it rises over in an oily substance. If some of it is thrown in the fire, it inflames. By this solution we learn, that not only a composed body has been produced, which may be decomposed into its former parts, but likewise a new one which did not appear at all in the original ingredients, that is, a fat inflammable oil.

PROCESS XXIV.

To dissolve the spirit of common salt with a fixed alcaline salt, and to make therewith a regenerated common salt.

Method.

Regenerated salt.

1. Pour liquified oil of tartar, diluted with twice as much water, in a cucurbit with a long narrow neck; make it quite hot, and drop some spirit of common salt into it, and a violent ebullition will arise; when this is over, shake the vessel, drop more spirit in, and so go on, 'till rightly saturated.

2. Filter it, let it evaporate to a pellicle, then crystallise it in a cold place, and you will have a salt

salt perfectly similar to common salt in taste and its cubical form.

PROCESS XXV.

To dissolve spirit of nitre with fixed alcaline salt, and to make therewith a regenerated nitre.

Method.

1. Dissolve any fixed alcaline salt in eight times as much clean water, filter it, and pour it in a cucurbit; make it warm; drop some aquafortis into it, shake it, and do the same again 'till no more ebullition or hissing is perceived. Regenerated nitre

2. Pour some more clean water to it, boil, filter it, evaporate to a pellicle, and let it shoot into crystals.

Observation.

1. The alcaline salt may be made of a vegetable alone, or of a vegetable and nitre, or of nitre alone, (see Process I. II. and III.) The same nitre is obtained with its long, pointed hexagon shootings, and all the other properties of nitre.

2. But if the nitrous acid is mixed with a fossile alcaline salt, then the crystals will shoot in a square form.

PROCESS XXVI.

To dissolve the acid of vitriol with fixed alcaline salt, and to make therewith a vitriolated tartar.

Method.

Vitriolated tartar. Dilute a pure oil of vitriol with three times as much water in a cucurbit with a long neck; drop successively as much oil of tartar in, as to be saturated, shake the glass well after each addition of the oil of tartar. But in order to find the true point of saturation, take a little out of the liquor, which must be neither of an acid nor alcaline taste: make it warm, divide it into two parts in two small phials; into one drop some oil of vitriol, in the other oil of tartar; that which you perceive to produce still an ebullition will discover which of either must be further added to the liquor in the cucurbit, either the acid or the alcali; for these points of saturation must be found very exactly, 'till absolutely no more effervescence is perceived.

2. Then pour more warm water to the mixture, in order to dissolve that part of salt which has settled at the bottom during the operation; filter it warm through a paper, evaporate it to a pellicle, and let it shoot into crystals, and a white salt is obtained, whose figure is octagon, and the points pretty obtuse on its pyramidical shootings. It has the name of *vitriolated tartar*, or *arcanum duplicatum.*

Obser-

Observation.

1. The same salt may likewise be obtained from crude vitriol when first dissolved in water, then the oil of tartar added 'till to the point of saturation, which then must be filtered, evaporated to a proper consistence, and then set to crystallise. But it must be nicely observed, if this salt shews any greenish or blueish colour, because then it cannot serve for medical use.

2. In this, and in the Processes XXIII. XXIV. and XXV. it is to be observed, that from a strong highly calcined, fixed alcali, and from a corrosive, pungent, volatile acid, a *neutre salt* is produced by the bare uniting of both in a due proportion, which then proves, instead of a pungent, quite of a mild taste; and in which the volatile acid is so entirely fixed, that it will melt in the fire without flying off.

PROCESS XXVII.

To dissolve a fixed alcaline salt with a strong acid, which had been before united with a weaker acid.

Method.

1. Dissolve a regenerated tartar in warm water; drop some spirit of salt, or spirit of nitre, or oil of vitriol, in the solution, 'till it is saturated; put the vessel over a very gentle heat, and the vinegar will go off,

but the remaining liquor, when evaporated and cryſtalliſed, will, according to the nature of the acid employed in the proceſs, produce either a kind of nitre or vitriolated tartar.

2. Diſſolve common ſalt in water, and add to it ſpirit of nitre; or diſſolve the nitre in water, and add the ſpirit of ſalt; diſtil it over, and you will have an aquaregis; let the remainder in the retort cryſtalliſe, and a ſaltpetre is produced, which however, beſides an admixture of common ſalt, differs in ſome reſpects from the common nitre.

3. Drop ſome oil of vitriol in a ſolution of ſaltpetre made with water; diſtil it over, let the remainder ſhoot into cryſtals, (ſee Proceſs X.) and a vitriolated tartar is obtained, the ſpirit of nitre being gone over in the receiver.

4. Drop ſome oil of vitriol in a ſolution of common ſalt made with water, diſtil it over, and bring the remainder to cryſtalliſe, (ſee Proceſs XI.) and you will have the ſpirit of ſalt in the receiver, and the ſalt of Glauber in the cryſtals, which are of an oblong hexagon figure.

Obſervation.

It does not appear if the nitrous acid works with more effect upon the alcaline part of the common ſalt, or the acid of the common ſalt more upon the alcaline part of ſalt-petre, as in both caſes either of the acids will riſe over and produce an aquaregis; and as likewiſe each expels the other in ſome degree from its alcaline part.

PROCESS

PROCESS XXVIII.

To dissolve the imperfect metals and semi-metals with a fixed alcaline salt in the dry way.

Method.

Take first the weight of the metal or semi-metal, then put it in a crucible, and mix or cover it with alcaline salt; for example, a fourth part; put a cover on, and give either a strong or gentle heat, such as the metal requires to its fusion After it has melted for a while, take it out, let it cool, break the crucible, and weigh the regulus, if there is any left. Solution of metals in the fire

Observation.

1. According to the nature of the metal employed, and to the strength and continuance of the given fire, the metal will be more or less destroyed, and the scoria prove of a different colour.

2. Hence by the assaying of ores upon any such metal, care must be taken that by the use of fixed alcaline salts, the metalline parts may not be destroyed, remain among the scoria, and consequently render the assay false.

PROCESS

PROCESS XXIX.

To dissolve copper with a fixed alcaline salt in the liquid way.

First Method.

Blue solution of copper. Take clean file dust of copper, moisten it with oil of tartar, keep it in a warm place; when dry, repeat the same as often as 'till thrice the quantity of the oil has been inspissated, then boil it in a proper quantity of water, filter it, let part of it evaporate, and the water will be changed into a beautiful blue liquor.

Second Method.

Put some drops of a copper solution made with aquafortis into one ounce of oil of tartar, and it will immediately thicken, at first into a green jelly, but soon into blue, 'till at last the whole liquor obtains the same fine deep blue colour.

Observation.

1. In the same manner iron may be dissolved with a fixed alcaline salt, yet every neuter salt, and even the pure water, and air itself, or rather the acid contained therein, will dissolve both these metals: hence it is that these metals are apt to rust so easily from any moisture, as well as from the air.

2. Filings

2. Filings of lead, or of tin, when boiled in an alcaline lye, may likewise be dissolved in that manner.

PROCESS XXX.

To make a fixed alcaline salt from bullocks blood; such as is required to the making of Prussian blue.

Method.

1. Put fresh bullocks blood in a pot over the fire, and part of it will congeal; throw away the liquid part, and bring the congealed part in a flat earthen pan over a gentle heat; stir it continually 'till quite dry, grind it to powder, and there will remain from one pound weight of blood only about six ounces of this matter. Prussian blue.

2. Make a fixed alcaline salt, as directed in Process II. mix it with the prepared blood, each the same quantity; put it in a pretty large crucible, begin with a gentle heat, and it will emit a fœtid smoke, and foam much up; increase the fire with care, that the mixture may not run over, and so go on 'till the fumes are gone off. Then pour it out in six times as much hot water as both parts did weigh before; let it either boil a little, or let it stay for some time in a warm place, then filter it, and keep the liquor for use.

PROCESS

PROCESS XXXI.

To dissolve gold, silver, mercury, zinc, and bismuth, with the same fixed alcali as prepared in the foregoing process.

Method.

1. Dissolve the gold in aquaregis, the other metals in aquafortis, as shall be shewn hereafter; keep of each solution one part, and the other part, except mercury, precipitate with a fixed alcaline salt, but the gold with spirit of salt armoniac.

2. Drop in the solution a little of the alcaline liquor prepared in the foregoing process, and it will at first precipitate the metal into a calx; but drop in more of the same liquor, and it will dissolve all the precipitated calx again.

3. Upon the calx which you had precipitated at No. 1. pour some of the same alcaline liquor, and it will dissolve the calx likewise.

Observation.

1. The making of this and the 36th Process should be postponed 'till it is shewn how metals are to be dissolved in their proper acids.

2. This alcaline liquor dissolves zinc better than bismuth; and more of the gold than of the silver.

PROCESS

PROCESS XXXII.

To dissolve spirt of common salt with a volatile alcaline salt, and to make therewith a regenerated salt-armoniac.

Method.

Dilute a good spirit of salt armoniac with twice as much clean water, drop into it as much of the spirit of common salt, as is just required to its saturation. Then let it pass through a filter, evaporate the liquor over a gentle heat to dryness, and a white salt will remain; which in a stronger fire will sublime and agree in every property with the common *salt armoniac*. Salt armoniac.

Observation.

1. The volatile alcaline salt has the same properties and effect as the fixed, except the fixity in the fire, in some qualities it even exceeds the fixed, as we shall see hereafter. Now as it dissolves the spirit of common salt, it makes indeed a kind of common salt, yet such as is not of a fixed, but of a volatile kind, and therefore is called *salt armoniac.*

2. From this process it seems to be possible that salt armoniac may be found native. For, a great quantity of volatile alcaline salts fly daily up into the air from the putrefied and burnt particles of animals and vegetables, and it is not improbable that nature in many places

places, by means of a continually repeated evaporation and inspissation, so as likewise by the uniting of vitriolic acids with the fixed alcaline part of common salt, may free and separate the spirit of common salt, whence those acids upon meeting together, may dissolve one another and therewith produce a salt armoniac.

PROCESS XXXIII.

To dissolve spirit of nitre with a volatile alcaline salt, and to produce therewith a regenerated semivolatile nitre.

Method.

Volatile nitre. When the spirit of salt armoniac has been diluted with twice as much water, drop as much of spirit of nitre into it, as is required to its saturation. If some oblong crystals should appear already in the liquor it must be diluted with more warm water, then filtered, evaporated till to the pellicle, and set to shoot into crystals.

Observation.

The crystals obtained in this process agree in every respect with the common nitre, except in fixity. They have the same oblong hexagone pointed form, the bitterish cold taste, and deflagrate with every phlogiston. In the fire they flux very easily like the other, but then they become volatile and dissipate.

PROCESS

PROCESS XXXIV.

To dissolve the vitriolic acid with a volatile alcaline salt, and to make therewith a semivolatile vitriolated tartar.

Method.

Proceed just as in the foregoing process, only that the oil of vitriol must be diluted with water.

Observation.

1. The salt obtained in this process, is pretty ponderous and compact, and agrees mostly with the fixed vitriolated tartar made after the 26th process, only that it is more penetrating and in the fire but semi-fixed. It is called *Glaubers secret salt armoniac.*

2. By this combination of the volatile alcaline salt, with the acids, the same is to be observed as has been said above with the fixed alcaline salts, viz. That from two corrosive hurtful salts, a mild, wholesome one arises after their solution; and here, from two volatile ones, a pretty fixed neutre salt.

3. Here a less quantity of the vitriolic acid is required, than in the foregoing process of the nitrous acid, and in that less of the spirit of nitre, than what in the 32d process was required

quired of the fpirit of common falt. Becaufe only the acids unite with the alcaline falt, and the water which was before united with the acid, is expelled, The proportion of the acid to the water is according to Homberg's experiment, as follows:

In the oil of vitriol, the acid is to the water as	37 to 23.
In the fpirit of nitre, as	31 — 74.
In the fpirit of common falt	97 -- 533.
In the vinegar - - -	9 -- 271.

For, to the faturation of one ounce of falt of tartar he has ufed;

Of vinegar ℥xiv. and obtained more falt after evaporation,	ʒiii+36 grain.
Of fpirit of com. falt ℥ii + ʒv.	ʒiii+14 —
Of aquafort. ℥i.+ʒii+30 grain	ʒiii+ 6 —
Of oil of vitriol ʒv.	ʒiii+ 5 —.

4 The fixed alcaline falt unites more readily with the acids, than the volatile alcali, therefore the volatile can be feparated and expelled from the bodies obtained in the 32d and 33d Proceffes, by a fixed alcaline falt; of which even the 4th Procefs, by the making of the fpirit of falt armoniac, gives an inftance.

PROCESS

PROCESS XXXV.

To dissolve copper with a volatile alcaline salt.

Method.

Pour upon clean copper filings twelve times as much spirit of salt armoniac, stop the phial and shake it frequently, and the spirit will in the beginning assume a corn-bloom colour, but at last changes into a deep violet blue. Then pour out the blue liquor, and fresh spirit upon the copper, repeat the same till the copper is all dissolved. A blue solution of copper.

Observation.

The minutest part of copper being dissolved in the urinous spirit, gives it a blue colour, which effect is only peculiar to that metal. By this means the presence of copper may be discovered in a white metal or in any metalline mixture, by adding only some of the volatile alcali. Therefore a silver calx may not be deemed perfectly pure, as long as it communicates to this spirit a blue colour.

PROCESS

PROCESS XXXVI.

To dissolve gold, silver, mercury, tin, and bismuth, with a volatile alcaline salt.

First Method.

Drop into an aquaregis, in which gold has been dissolved, and into an aquafortis in which silver, mercury, tin, or bismuth, has been dissolved, a good spirit of salt armoniac, and part of it will precipitate in the beginning; but drop in more of the spirit, and all that had precipitated will be dissolved again.

Second Method.

Precipitate the gold solution made with aquaregis, in the same manner as above with the spirit of salt armoniac, but the silver, tin, and bismuth-solution with a fixed alcaline salt, or with liquified oil of tartar; pour upon the precipitated calces this spirit of salt armoniac, stop the phial, and all the calces will be dissolved again, yet more of the silver than of the gold.

Observation.

1. After it had been observed that a volatile alcali will precipitate a metal which was dissolved in acids, it was not to be expected that the same salt should likewise at one and the same

same time dissolve the same metal again; which it had just precipitated, and so produce two effects which appear directly opposite: Yet if rightly understood, it does not infer any contradiction. For though this volatile alcali will dissolve metals, it dissolves however much more readily the acid spirits. When therefore this alcaline spirit is successively brought into an acid wherein a metal has been dissolved, it unites most readily and instantly with the acid, and makes it depart from the metal so as to let it fall down in a precipitate. (calx.) But when afterwards more alcaline spirit is added than the acid requires to its saturation, it exerts and recovers the same power it had before to dissolve the metalline calx itself, after the acid is broke and deprived of its action.

2. The gold which has been dissolved in the armoniac spirit, will precipitate by itself when brought in a warm place, and exposed to the open air, but the silver instead of precipitating, shoots into crystals; however, if desired, it may be precipitated with salt-water, or with spirit of common salt.

PROCESS XXXVIII.

To make vinegar stronger by itself without any addition.

Method.

When put in a high alembic, distil half of it over in the receiver with a very gentle heat; and that Strong vinegar.

that which rises over will be light, watery, and of little or no taste; but the remainder will be a strong pungent vinegar.

Observation.

Vinegar is heavier than water, therefore in a gentle heat the water rises first, and carries but a very small part of the acid along with it over: the remainder being by that means deprived of the most part of water, must needs be stronger and sharper than it was before. From this depends the solution of animal and vegetable substances, such as flesh, horn, bones, &c. when boiled for a long time in vinegar; because the vinegar being deprived, during the boiling, of most of its aquatic parts, grows stronger, so that being assisted by the motion of fire, it is able to dissolve those bodies.

PROCESS XXXVIII.

To make vinegar stronger by means of Spanish verdigris.

Method.

1. Grind the verdigris to powder, put it in an alembic, and as much vinegar into it as to cover it some inches; bring it in a warmth of the 150th degree of Farenheit's thermometer, stir it often with a wooden stick 'till the vinegar has acquired a very deep green colour, then pour the liquor off that all sediments may remain behind. Pour fresh vinegar upon the remainder, and repeat this in the same

ſame manner as long as the vinegar is tinged green, and a great deal of muddy ſubſtance will remain behind undiſſolved.

2. As much as you have collected of this vinegar, diſtill it out of an alembic with a gentle gradual heat, 'till a pellicle appears on the ſurface in the alembic; and that which is gone over, will be a clear watery liquor of little or no taſte.

Bring then the alembic with the remaining liquor in a cold place, and it will ſhoot into fine cryſtals of a beautiful deep green, from which the liquid part muſt be poured off, evaporated, and again brought to cryſtalliſe, and this as often as any cryſtals will ſhoot. Theſe cryſtals muſt be very gently dried, not near a fire, but only in a warm air, or warm room; for when ſuddenly or too warm dried, they loſe their brightneſs. They are commonly called *diſtilled verdigris*.

3. Put thoſe cryſtals in a glaſs retort, and give fire by degrees, and but a ſmall quantity of water will go over at firſt, which muſt be thrown away; but then the vinegar comes over in oily curved ſtrias, and is the ſtrongeſt acid of that kind which can be made. In the retort a corroded copper remains at the bottom, which may be diſſolved with freſh vinegar, and reduced into cryſtals as above.

Obſervation.

1. Here the *vinegar* is deprived of a great part of its water, whence it muſt grow ſtronger; and yet the vinegar ſuffers no alteration by the diſſolved copper, but may be entirely

S ſepa-

ſeparated from that metal without acquiring any of its corroſive quality, ſmell or taſte. This metal is the only ſubſtance in nature which admits of that method and produces that effect with vinegar: for gold, ſilver, and mercury are not at all affected by it, and tin but very little; and though it diſſolves the lead, yet when the liquor is diſtilled off, there is no more vinegar, but a fat oily ſubſtance obtained, entirely changed from its firſt acidous nature. The ſame happens with iron, which, though vinegar diſſolves it partly, yet when diſtilled off, it is nothing but water, though very much altered. If alcaline, fixed or volatile, or any other bodies, have been diſſolved with vinegar, it can never be ſeparated from any of them in its former property as a pure acid.

2. *Vinegar* may likewiſe be made ſtronger by means of cold, when after it is frozen to ice, that part which remains liquid may be poured off, and kept by itſelf as a ſtrong vinegar. For, as vinegar conſiſts but of a ſmall portion of the acid ſalt, and of a great deal of water, and this being the ſooneſt frozen to ice, a great part of it may be ſeparated from the vinegar by that means.

PROCESS

PROCESS XXXIX.

To diſſolve lead in vinegar, and to make therewith *white-lead.*

Method.

Fill a large ſtill-head with laminas of lead, place them ſo that they may not fall down; apply the helmet to an alembic in which you have put diſtilled or other good vinegar, diſtil with a very gentle heat for the ſpace of ten or twelve hours; let all cool by itſelf without moving any of the veſſels; then take of the helmet, put the lead to dry only in a warm place, and you will find it covered with a white powder, which is the *white lead*, and muſt be collected with bruſhing it off from the laminas. This operation being repeated ſeveral times, all the lead will be reduced into white lead. Part of the lead has been diſſolved by the vinegar, and carried over with it into the receiver, and has no more any acid, but a nauſeous ſweetiſh taſte, out of which the diſſolved lead may be precipitated with an alcaline ſalt. White lead.

PROCESS XL.

To diſſolve any calx of lead with vinegar, and to make therewith *ſugar of lead.*

Method.

1. Put white lead, minium, or lytharge in a high glaſs cucurbit; pour twenty times as much Sugar of lead.

good vinegar upon it, boil it gently for the ſpace of four hours, ſhake it frequently, and then filter it. Pour other vinegar upon the remainder, proceed as before, and this as often as 'till all the calx is diſſolved.

2. Let all the collected and filtered vinegar evaporate in a low alembic, or in any veſſel of glaſs, (of ſtone) to the thickneſs of honey; then bring it in a cold place, and a ſalt will collect in the form of fine ſmall ſpiculæ, all in an erected poſition; pour the liquor off, and let the ſalt gently dry, and it will be ſweet as ſugar, whence it has the name of *ſugar of lead.*

Obſervation.

1. Neither the lytharge nor minium when diſſolved in vinegar, will paſs ſo eaſily through the filter when cold as the ſolution of white lead; therefore they muſt be filtered when warm. The ſolution before it is evaporated, is called *lead vinegar*, likewiſe *virgin milk*, named ſo from its uſe; for, when diluted, it goes for a coſmetic to whiten the ſkin, and take off pimples and eruptions, but is a very pernicious and dangerous thing.

A dangerous coſmetic.

2. This vinegar, when evaporated to a fourth part, and freſh vinegar poured upon the remainder, then again evaporated to the thickneſs of honey, part of the vinous acid remains united with the diſſolved metal, and then the fat oily ſubſtance obtained therewith is called *lead-oil.* The oftner the ſame method is repeated

Lead oil.

peated, the fatter will be the oily substance, and with the more difficulty it is brought to dry.

3. If the sugar of lead is again dissolved in fresh vinegar, evaporated to the thickness of oil; the sediments left to collect by themselves at the bottom, then the clear poured off and brought in a cold place to shoot again, the crystals will be much larger and compacter than before, and perfectly similar to sugar in taste and form. The same solution and inspissation being repeated again, then a juice is obtained, which in a gentle heat will hardly liquify, but when given in a greater degree, runs like wax.

4. *Sugar of lead*, when distilled by degrees out of a retort, a fat inflammable spirit rises over, after the fire has been increased to a great degree, in which nothing more of vinegar may be discovered *

PROCESS XLI.

To dissolve copper with vinegar, and to make therewith a kind of verdigris.

Method.

Proceed in the same manner with laminas of copper as in the foregoing process with the lead, and Verdigris

* And of which the author could probably give further advice, if the place would allow.

and the diftilled vinegar will be of a green colour, and of a very difagreeable ftyptic tafte, which by evaporating part of it, obtains a deep emerald colour. Upon the copper lamina a verdigris or copper-bloom arifes.

Obfervation.

1. Since the copper will diffolve in an acid of fo weak a kind, and as but one drop of that folution is fufficient to caufe a violent vomiting, this proves not only how eafily copper is corroded, but how careful we fhould be in the dreffing of meat, or preparing any thing in copper veffels which contains the leaft part of acid. This inconveniency is thought to be prevented by the tinning of thofe veffels, yet it is by no means fufficient, becaufe there will either fome fmall imperceptible parts remain uncovered with the pewter, or fuch fmall minute parts will arife in time by the ufe of the veffel, which being then expofed to the effect of acids, will produce the fame danger.

2. This verdigris agrees neither in colour nor in the means of preparing with the common verdigris; becaufe the other is made of copper with the hufks of grapes employed to this purpofe, after the muft has been expreffed, and is by far not fo pure as this which confifts only of the acid and of copper, but leaves a great deal of fediment behind, after being diffolved in vinegar. (See Proc. XXXVIII.)

PROCESS

PROCESS XLII.

To dissolve calcareous earths and stones, likewise iron, tin, and bismuth with vinegar.

Method.

Pour upon any of these bodies about twenty times as much vinegar; boil it in an alembic of glass for some hours, filter then the liquor, repeat the same with the remainder 'till all is dissolved.

Observation.

1. The solution of iron is of a reddish colour, and sticks so fast to the glass, that it will hardly wash off. But the other metals above named, communicate no colour at all to the vinegar.

Zinc and iron loose their metallic lustre; the first becomes dark and blackish, the iron brownish yellow, and can never be dissolved all in the vinegar, but leaves the greatest part unaffected behind; so that this solution may only be reckoned like an extraction of some constituent part of the iron. The remainder of the bismuth in this solution retains even its metallic lustre.

2. It being usual to give to the pewter a hardness by an admixture of zinc, or of bismuth, or of regulus of antimony; and as this latter does by far not so easily dissolve in a weak acid,

acid, like the zinc and bismuth, it is much better and safer to take the regulus of antimony to those compounds of which pewter-vessels are made for kitchen use.

PROCESS XLIII.

To precipitate such bodies as have been dissolved in vinegar.

First Method.

Precipitation. Drop either of a fixed or of a volatile alcaline salt, dissolved in water, as much into the solution, 'till you see that no more clouds ensue from the falling in of a single drop. Let the liquor settle, and when clear, pour it gently off from the calx which has settled; then edulcorate the calx with warm water, repeat this as often as 'till the water comes off tasteless, then bring the calx to dry.

Observation.

1. Since we know that every acid dissolves more readily an alcaline salt, than any other body, it unites instantly with this, and leaves that body which it had dissolved before, which then separates, and falls by itself to the bottom. Yet since it is always the case that some particles of that body which produces the precipitation, unites and coheres with the precipitated body; and as this is here a salt, it must be separated from the precipitated

from

body, by means of water, which operation is called *edulcoration.* Edulcoration.

2. The bodies which have been precipitated, are called *magisterium*, sometimes, and when made of metals, they have the name of *crocus*, or in general *calx*. They differ in colour, partly with respect to themselves, partly with respect to the bodies with which they have been precipitated.

3. Since sometimes such bodies which have been dissolved by a weak acid, may, instead of alcaline substances, be precipitated with a stronger sort of acid, the sugar of lead when dissolved in water, may be precipitated with oil of vitriol.

PROCESS XLIV.

To dissolve calcareous earths and stones with the acid of vitriol.

Method.

Pour upon quicklime or chalk, or upon a calcareous spar, as much spirit or oil of vitriol, as to make the ebullition cease, let it remain for some time in a warm place, then pour some water to the mixture, filter the liquor, then evaporate, and bring it into a cold place to chrystallise, and you will find fine crystals of a feather-like appearance, quite tasteless and insoluble in water. Solutions with oil of vitriol.

Observation.

Observation.

It has been obferved that by the affaying and examining of ores and ftones in clofe veffels, the fame kind of taftelefs and infoluble cryftals have been obtained, collecting in the neck of the retort after a ftrong fire has been given. Thefe cryftals may then, by all probability, not have been contained originally in the ore, but, as we may judge from the above procefs, may be produced during and with the operation itfelf, that is, from a calcareous earth contained in the mineral, and from the vitriolic acid.

PROCESS XLV.

To diffolve partly the clay with oil of vitriol, and to make therewith a kind of allum.

Method.

Solutions with oil of vitriol.

Pour oil of vitriol upon a white clay in a glafs retort, lay the veffel in a fand-coppel, and rife the heat fucceffively to a ftrong degree. When all the liquid is over, pour upon the dry remainder warm water, which will extract the falt, then filter that water, let it evaporate till a pellicle appears on the furface, and fet it to fhoot, and you will find very fine tender cryftals of an aftringent fweetifh tafte.

Observation.

1. When this folution is precipitated with a liquified oil of tartar, a calcareous earth will fall

fall down, which effervesces with every acid like the edulcorated earth of allum. This calcareous earth must therefore be either concealed from the beginning in the clay, or it is produced actually with the admixture of the vitriolic-acid.

2. As the crystals obtained in this process agree pretty near with the allum, and as the matrix of allum is an argillaceous earth, or common rock, or a fossil of the clay kind, called *letten*, and as, besides this, those crystals obtained in the preceeding process have not the least likeness with alum; we may conclude with all probability that the fundamental earth of allum cannot be of a calcareous, but must be of an argillaceous kind, or at least such as is actually contained in clay.

PROCESS XLVI.

To dissolve iron and zinc with oil of vitriol, and to make therewith from the iron an iron-vitriol, and from the other a zinc-vitriol (Gallizen-stone.)

Method.

1. Pour upon *iron-filings*, or upon the *zinc*, the same quantity of oil of vitriol as the metal weighs, and two or more parts of water according to the strength of the oil, and it begins immediately to dissolve the metal with a violent ebulition, and to emit thick fumes, which prove from zinc of a ful-

sulphureous, and from the iron of a garlick-like smell, and, they may be of the iron or zinc, will, if done in a narrow vessel, take fire if held to a lighted candle, and burst the vessel in pieces, unless it is very strong, or the mouth of the glass immediately stopped.

2. After the solution, a black earthy sediment remains at the bottom from both these metals; before you filter, pour more water to it, to prevent its corroding the paper, then filter it, evaporate, and set it to shoot, and you will have crystals of vitriol, which from the iron are of a greenish colour, but from the zinc, white and much like the shootings of salt-petre.

Observation.

1. When into the liquor which remains after the shooting of the iron-vitriol, fresh iron-filings are brought and some water added, it dissolves the iron again, so that this evaporating crystallising and dissolving may be continued as long and often as any part of the vitriolic-acid remains in the liquor. According to Kunckel's experience, there may, by this method, more than three pounds weight of iron-vitriol be made, with one pound weight of the oil of vitriol.

Zinc-vitriol (gallizen-stone.)

2. Zinc-vitriol has been made long ago without ever knowing that this semi-metal was contained in the substance. But in order to be convinced of it, dissolve this vitriol in water, precipitate it with an alcaline-salt, mix the precipitated calx with one eighth part

part of charcoal dust, and distil it out of an earthen retort with a strong fire. Break the retort, and you will find the zinc in its metalline lustre and form in the neck of it. Or take the precipitated calx, bring it in the fire with copper, and it will make brass. Zinc Brass

PROCESS XLVII.

To dissolve silver, copper, lead, tin, bismuth, regulus of antimony, and arsenic, with oil of vitriol.

Method.

Pour upon any of those metals, which shall either with filing or otherwise be made small, and put in an alembic, cucurbit, or any proper glass, twice as much oil of vitriol as the metal weighs, bring the vessel in a sand-coppel, and let it boil nearly to dryness. When it has done bubbling, it is the sign that the solution is performed; then pour warm water to it, and let it pass through the filter.

Observation.

1. To the solution of silver no water must be added, else part of it will precipitate by itself.

2. So soon as water is poured to the solution of copper, it turns into a bluish green colour, and gives after the evaporation and crystallisation,

tion, a fine copper-vitriol, and the remaining liquor will dissolve more copper, so as it did with the iron.

PROCESS XLVIII.

To dissolve part of the mercury with oil of vitriol, and to make of it *turbith of mercury*.

Method.

Turbith of Mercury. 1. Pour upon live quicksilver, in an open sugar-glass, as much of the best oil of vitriol as the metal weighs, bring it in a sand coppel uncovered, give first a gentle heat, and then rise it more and more till it fumes no more, and a very white but excessively corrosive powder remains.

2. Grind this matter, while warm, to a fine powder in a glass-mortar, and throw it immediately in twenty times as much warm water, which you have ready in a high edulcorating glass, and while it falls down through the water, it will turn into a citron-yellow powder; shake the glass well, let it settle, then pour the water gently off, and other warm water upon the powder, and this as often till the powder proves quite tasteless, and so you have the *turbith of mercury*.

3. Let all the water collected from the edulcoration, evaporate, and bring it in a cold place to shoot, and you will have *crystals of mercury*. Or drop into that water some oil of tartar, and a reddish powder will precipitate.

Observation.

Obſervation.

1. If the chimney under which this operation is performed, ſhould not be of a very good draught, it is better to do it in a cloſed veſſel, and to diſtil the oil of vitriol off from the mercury in order to avoid the moſt pernicious and poiſonable fumes.

2. The oil of vitriol exerts here two different effects upon the mercury; firſt, it diſſolves part of it, ſo that this part unites entirely with the water: Secondly, it reduces the other and greater part of the mercury into a powder which proves in a great degree fixed in the fire, becauſe it melts in a ſtrong melting-heat into a blood-red ſubſtance, without flying off.

PROCESS XLIX.

To precipitate the terreſtreous and metallic bodies diſſolved with oil of vitriol.

Method.

1. This may be performed in the ſame manner as has been ſhewn in Proceſs XLIII. either with a fixed, or with a volatile alcaly, ſo as likewiſe this may be freed again by the other.

2. This precipitation may likewiſe be performed by means of a metal, that is, when in the ſolution ſuch a metal is immerſed which the oil of vitriol will diſſolve more readily than that contained in the

the solution, for example, by putting a piece of iron in the solution of copper. And this is the principle of the *cement-copper*, so called, as it is produced in Hungary and other places from springs and other waters containing a copper-solution made by nature.

Observation.

With those bodies which, according to the instruction given in the several foregoing processes, will dissolve again with alcalies, one must take care to bring no more of the alcaly into the solution, than the acid requires just to its saturation, because, if added in a greater quantity, the alcaly would dissolve the precipitated calx again. Water being poured in this solution of silver, part of it will precipitate by itself, but the other part unites with the water, out of which the silver may be precipitated with aquafortis, or spirit of common salt, or only with salt-water.

PROCESS L.

To dissolve calcareous earths and stones with the acid of nitre and to make from chalk, Balduin's phosphorus.

Method.

Phosphorus. 1. Pour four parts of spirit of nitre upon one part of a pure alcaline earth, and it will dissolve with great violence; but no fumes will rise from this solution as it does with metals.

2. Let

2. Let the solution evaporate in an open glass vessel to dryness, put the remainder in a flat earthen pan, bring it under a heated muffel, so that at first it may only come gently to dry, then let it grow red-hot; and this matter will from the sun or from any fire become luminous and shine in the dark, then lose its light, and receive it again when exposed to the sun or fire. This *phosphorus* has its name from the inventor, *Balduin.*

Observation.

The *bononian phosphorus*, so as all those coloured Fluors frequently found in mines, having nearly the same phosporic quality, the nature of their constituent parts may be judged of in some measure from these effects.

PROCESS LI.

To dissolve silver in aquafortis, and to make crystals of silver.

Method.

1. Take pure silver, either beaten in thin lamina, or granulated, which latter must be made in this manner: When melted in a clean crucible, pour it in a pail of water through the besom, so called, which is, to hold the besom in the water and stir it round, while the silver is poured into it, by which means it falls into small grains, which are for the most part hollow within. Silver crystals.

2. Upon this granulated silver pour twice as much of good prepared aquafortis, and immediately a great many small bubbles will appear upon the silver, which soon rise up, and while they ascend, grow bigger, but so soon as arrived to the surface, burst and disappear. The aquafortis being brought thereby in a motion, grows hot and begins in some degree to boil, and then it emits red fumes, 'till at last it has swallowed up all the silver without changing its colour, but its taste becomes very fiery and extremely bitter and pungent.

3. Put some more silver grains successively in the same solution, till you see that, after a long while standing, some silver will remain undissolved at the bottom, whence you may judge that the aquafortis has been entirely saturated; then bring this solution in a cold place, leave it there unmoved for twelve or more hours, and a salt will shoot of very tender crystals and a triangular form, consisting of fine white plates joined closely one upon another; they are called *salt of silver*, *silver-crystals*, *silver-vitriol.* They will not readily become dry.

If the aquafortis has not been so entirely saturated as above directed, it will not shoot into crystals until the solution is deprived of part of its water by a gentle evaporation.

Observation.

1. When silver is put in any common unprepared aquafortis, it turns immediately into a milk-white colour, which renders it foul and settles at last a small portion of a white calx at the bottom, which

which being melted with a fixed alcaline-ſalt produces a corn of ſilver. The reaſon why every unprepared aquafortis ſettles this part of ſilver, is owing either to a portion of the vitriolic-acid, or of the common-ſalt which has introduced itſelf among the aquafortis by the making of it; for both theſe ſpirits precipitate the ſilver in the ſame white calx after it has been diſſolved in the nitrous acid, of which that of the firſt, (the vitriolic acid) proves of a refractory, but the calx of the latter (the common-ſalt) of a fuſible kind in the fire. Before therefore an aquafortis can be uſed to make a perfect and clear ſolution of ſilver, it muſt firſt be freed of that ſpirit of the vitriol or of the common-ſalt, which is done in the following manner: Take a thirtieth or fortieth part from the whole quantity of your aquafortis, in a litttle phial, and throw as much ſilver into it as to be quite ſaturated, and it will immediately grow foul and milk white, let it either ſettle by itſelf for a day and night, or filter it through a paper while warm, then put it by drops into the whole quantity of your aquafortis, and each drop will produce a thick milk-white cloud; this muſt be left to ſettle till clear, and then let ſome more drops fall into it, and it will make the ſame clouds; let it ſettle, and repeat the ſame till it makes no more clouds. When all has ſettled, pour your aquafortis out from the ſettled calx into another veſſel, keep it well cloſed with a ground glaſs-ſtopper which fits the mouth of it perfectly; and now it is fit for the uſe of making a perfect ſilver ſolution,

Prepared aquafortis.

and it is called *prepared* or *precipitated aquafortis.*

2. Most silver after it has been dissolved, leaves a black powder at the bottom, which powder is the gold contained in the silver; for gold is not affected by aquafortis. Hence gold may may be parted from the silver by this means. This separation is known by the name of *parting by the quart*; for it has been found by experience, that if one third of gold is united with silver in fusion, the best aquafortis will not touch the silver; but if the silver exceeds two thirds, that is, by four or more times the gold, then the aquafortis dissolves the silver; and the more the quantity of silver increases the greater is the action of the aquafortis upon the silver; therefore the usual proportion is a fourth of the gold in weight to the silver, in which proportion not only the solution succeeds perfectly well with respect to the silver, but the gold remains then in its native form and brightness, and even in the same figure which the lamina of silver had when brought in the aquafortis, by which means it is less apt of being lost then when reduced into a small powder. Hence this method is mostly made use of by the refiners, and called the *parting by the quart.*

Parting by the quart.

3. If the solution of silver shews a greenish colour, it proves that the silver was not pure, but contained some copper.

4. The

4. The ſolution may be diluted with a pure water, without being precipitated by it, as it was the caſe with the ſilver ſolution made with oil of vitriol: and ſtill after being diluted with water, the ſolution remains ſo ſtrong and pungent as to ſtain the ſkin black, which ſtain cannot be taken off but by rubbing either the ſkin off with charcoal, or leaving it time to wear off by itſelf. Therefore the hardeſt ſubſtances may be ſtained with this ſolution before it has been diluted with water, ſuch as marble, agat, jaſper, and perhaps china; and if thoſe ſtones are covered with wax or any reſinous matter as may not be affected by aquafortis, then figures are drawn in the wax or reſin with a ſharp ſteel point, ſo as to make a ſlight inciſion, and the aquafortis poured upon it, the figures will be *etched* into the ſtone. If it is done upon marble, and moiſtened ſeveral times with the aqua-fortis, the ſtaining will enter an inch deep. But if the leaſt part of any ſaltiſh matter ſhould be contained in the water with which this ſolution has been diluted, the whole liquor turns inſtantly foul and cloudy. Therefore water or any other liquor may very eaſily be dried by that means, to diſcover if it has any admixture of a ſaline kind.

To ſtain marble

5. In caſe the ſolution has not been perfectly ſaturated with ſilver, but part of it evaporated to obtain the ſilver-cryſtals, they will contain a greater quantity of the acid than the other, and therefore are by far more corroſive than thoſe made from a ſaturated ſolution. Silver-

crystals, or even the solution of silver being evaporated in a flat glass vessel to dryness, then melted, and poured out into an ingot, the substance obtained therewith is called, *lapis infernalis*, which is made use of by the surgeons to corrode and eat away proud flesh.

Lapis infernalis.

6. The same silver crystals being dissolved in water, and that water, or even the aquafortis in which the silver has been dissolved, is poured into water in which salt-petre has been dissolved, the silver does not precipitate, but unites readily with the salt-petre. This mixture when evaporated and set to shoot, the crystals obtained consist of silver and salt-petre united together, and are perfectly similar to real salt-petre in form and appearance. This art has been made use of by some cheating fellows in this manner; they desire you to melt any kind of lead in a crucible, then to throw in some of these salt-petre crystals, when the lead proving afterwards pretty rich of silver, they give out to have the lead transmuted into silver. This deceit is discovered by dissolving these crystals in water, and putting a piece of copper into the water, and the silver soon falls down and collects upon the copper. For, as the nitrous-acid dissolves the copper more readily than the silver, it instantly takes hold of the copper, and leaves the silver at liberty to fall down and collect by itself in its metallic form.

A cheat.

7. These

7. These silver crystals when brought upon a lighted charcoal, in which a proper cavity has been cut out as a receptacle, they inflame like salt-petre, burn away, and leave the silver pure behind.

PROCESS LII.

To precipitate the silver dissolved in the preceding Process with the acid of common salt, and to make from the precipitated calx a *horn-silver*, (*luna cornua.*)

Method.

1. Dilute the silver solution with four times as much of pure water, drop some warm water into it, in which common salt has been dissolved, and it will immediately turn into a thick milk-white liquor; shake it and leave it a while to settle, then drop more of the warm salt-water in, repeat the same 'till you see no more white clouds appear from any drop of the salt water. Then you may let it remain to settle and clear for some hours, try once more if a drop of salt-water produces any cloud, and if not, let it quite settle, then pour the liquor gently off from the calx, which must be edulcorated with warm and clean water, and this as often repeated till the water comes off without any saltish taste. Lastly, let the calx boil for a little while with clean water, let it settle, or pass through the filter, dry the calx gently, which will have increased half in weight of the silver employed. Luna cornua.

2. Put

2. Put this calx in a clean crucible, make a circular fire round it, increaſe and bring it ſucceſſively near to the crucible till it melts, which this matter will do very eaſily, then pour it inſtantly out upon a ſmooth marble, and you will have a ſhining, opake, browniſh, pretty tough and heavy ſubſtance, ſimilar in appearance to horn, whence it has the name of *luna cornua* (*horn ſilver.*)

Obſervation.

1. The ſalt-water which is added to the ſilver-ſolution, changes the aquafortis into an aquaregis; and though aquaregis does not touch the ſilver, yet the ſalt unites in this operation ſo intimately with it, that it cannot be expelled from the ſilver by fire alone, like the aquafortis, but would, without ſome other aſſiſtance, rather render the ſilver volatile and carry it off in fumes if raiſed to a great degree. To reduce therefore the ſilver and to obtain it again from the *luna cornua*, ſome ſubſtance muſt be added with which the acid of the aquaregis, (which is that of the common-ſalt) unites more readily than with the ſilver; and this may be done either with a fix'd alcaline-ſalt, or with a phlogiſton, ſuch as oil, or any fat ſubſtance; add, therefore, one or the other to the horn-ſilver, melt it in a clean crucible, and you will have the ſilver again without loſs.

2. If, inſtead of ſalt-water, a ſpirit of common-ſalt is dropt in the ſolution, it makes likewiſe an aquaregis, and conſequently the ſame horn-ſilver is obtained. Another method of making horn-

horn-silver is this: Take a silver calx which has been precipitated with copper, mix this calx with twice as much of a dry sublimed mercury, put this mixture in a retort and distil in sand-heat with the strongest fire.

Horn-silver is no further affected neither by aquafortis nor aquaregis, but only the oil of vitriol will dissolve part of it.

PROCESS LIII.

To dissolve mercury and lead with aquafortis, and to make the crystals thereof.

Method.

1. Pour one part and a half of a good aquafortis upon one part of mercury, set it warm, and the mercury will appear to boil at the bottom of the phial, and disappear by degrees. When all is dissolve put some more mercury in, till at last a little of it remains undissolved at the bottom, and then the aquafortis is saturated. This solution remains clear and transparent like water, is of a very pungent taste, but of no other smell than that of the aquafortis. Solution of mercury.

2. Dilute a common aquafortis with ten times as much water, pour fourteen parts of it upon one part of granulated lead, or upon a calx of lead, and it will make a strong ebullition and raise a white scum. When this is over, leaving it for some Of lead.

ſome hours to boil, then let it ſettle, cool, and paſs through the filter.

Cryſtals of mercury.

3. Pour the ſolution of No. 1, while warm, in a cold glaſs veſſel, let it ſettle, and a white ſaltiſh tranſparent ſubſtance will collect at the bottom. Pour the liquid part off from thoſe ſediments into a glaſs veſſel, and let half of its quantity gently evaporate, then put it in a cold place and it will ſhoot into cryſtals.

Lead cryſtals.

4. Let the ſolution No. 2, evaporate till to the pellicle and let it ſhoot in a cold place, and you will find very ponderous compact cryſtals, of a ſweetiſh, yet more adſtringent taſte, than thoſe made with vinegar.

Obſervation.

1. Of all the metals which may be diſſolved with aquafortis, only ſilver, lead, and mercury, can be made into cryſtals by this acid; none of the other metals.

2. The cryſtals of lead and mercury do not inflame like thoſe of ſilver, nor deflagrate with a phlogiſton like theſe of the ſalt-petre. On the contrary, the cryſtals of lead rattle and fly in the fire with great violence and danger. But when rubbed into a very fine powder, then they may be melted in the ſtrongeſt fire without any difficulty.

3. The mercury diſſolved with aquafortis, when put in a retort, and the liquid part diſtilled of

as

as much as will raise over in so gentle a heat without coming to boil, a weak aquafortis will be obtained in the receiver. If then the retort with the remaining liquor is brought in a sand-heat and the fire somewhat stronger given, till the red vapours begin to rise over, a good and strong aquafortis will be obtained in the receiver. If then the receiver is changed again and the fire increased by degrees, the receiver will be all filled up with red vapours, and the spirit of nitre collected therein, be of an excessive strong kind, so that many years after it will push out red fumes, if it has been kept well stopped. The fire being afterwards suffered to go out by itself and the retort cooled, a compact deep red substance is found at the bottom, and the rest which has sublimed up to the neck of the retort, of various colours, some white, yellowish, yellow, greenish, and red. This red corrosive substance at the bottom is called *mercurius precipitatus ruber.* (the red precipitate of mercury.)

The strongest fuming spirit of nitre.

Mercurius precipit. ruber.

PROCESS LIV.

To dissolve iron, copper, tin, bismuth, zinc, regulus of antimony, arsenic, cobalt with aquafortis.

Method.

Throw but a little of the metal, which must be reduced into small pieces, in the aquafortis at a time,

Solution with aquafortis.

time, and when the first violence of the acid is over, another piece, and this so long till it will dissolve no more. If iron, zinc, or copper, shall be dissolved, the aquafortis must be diluted with two or more parts of water, according to its strength.

Observation.

1. One should never put too much metal at once in the aquafortis, because the action of the acid will be too violent, the aquafortis become too hot, expell too much at once of its spirit in red fumes, loose thereby the best part of its power, and can consequently not dissolve the same quantity of metal as it may in proportion by the above method. These fumes will even carry off some part of the metal; and the solution of tin is rendered quite unfit to the dying of scarlet when ever it has thrown out any of these red fumes.

2. Tin, regulus of antimony, and arsenic, will but partly dissolve, the rest is only corroded into a calx by the aquafortis.

PROCESS LV.

To precipitate those metals which have been dissolved in aquafortis.

Method.

1. Put in the solution another and such a metal which the aquafortis will dissolve more readily than

than that which has been diſſolved therein, for example; in the ſolution of ſilver, a piece of copper; and the aquafortis will inſtantly lay hold of the copper to diſſolve it, leave the ſilver, and make it fall down in its metallic form. The order in which metals are diſſolved by aquafortis, is thus: It diſſolves the ſooneſt and readieſt of all, *zinc*, then *iron*, then *arſenic*, after this *cobalt*, then *copper*, then *biſmuth*, then *lead*, then *mercury*, and at laſt *ſilver*.

2. Or, drop an alcaline ſalt diſſolved in water, into the ſolution, but let it be no more than the aquafortis requires to be ſaturated, and the metal falls immediately to the bottom in a fine calx, which, when quite ſettled, and the liquor poured off, muſt be edulcorated with warm water, till the water comes off without any ſaline or acid taſte. But if more of the alcali is put in than the aquafortis requires to its ſaturation, ſuch calces as are affected by the alcaline ſalt, will be diſſolved again, and then nothing remains of the intended precipitation.

3. In the ſolution of *lead* or of *mercury*, drop a ſolution of common ſalt made with water, and both will precipitate into a white calx. Edulcorate thoſe calces and dry them gently. The calx of mercury is called *white precipitated mercury*.

White precipitated mercury.

4. *Biſmuth* will precipitate by itſelf only with adding about eight parts of water to the ſolution. The precipitated powder is uſed as a coſmetic to paint

Spaniſh white.

paint the skin white, and is known by the name of *Spanish-white, blanc d'Espagne.*

Observation.

1. Silver may likewise be precipitated with mercury into a white calx, but as mercury dissolves the silver by itself, it constitutes an amalgama therewith. Upon this operation depends that curious preparation of the *Arbor Dianæ*, so called, viz. Dissolve one part of silver in two parts of aquafortis, pour three parts of water to the solution, then put two parts of mercury in, and let it stand unmoved, and there rises an amalgama up, which spreading out in many branches similar to a tree, has given that name of *Arbor Dianæ*. But the following method may be preferable. Put an amalgama of silver and mercury in a phial of fine clear glass, put it for a time in a gentle heat, increase it very gently by degrees and in some days you will see not only a tree but a whole bush in the glass.

Arbor Dianæ.

2. If a body dissolved in aquafortis shall be precipitated by another acid, it will succeed best when that acid is of such a kind as will hardly or not at all dissolve the same body which has been dissolved in the aquafortis; or if it makes such a compound with the aquafortis by which the dissolved body may not be affected at all. In the first case silver may be precipitated out of the aquafortis by oil of vitriol, because this will not touch the silver,

except

except when concentrated and without any admixture of water, and even in its concentrated ſtate, it requires a ſtrong boiling heat to diſſolve it. In the ſecond caſe, if ſpirit of common ſalt is put into the ſolution of ſilver it makes an aquaregis, and as this cannot affect the ſilver, it muſt likewiſe fall down by itſelf. But if you would precipitate zinc with common ſalt, or with its ſpirit, or with oil of vitriol out of the aquafortis, your labour would be in vain, becauſe zinc will diſſolve with all theſe acids as readily as with the aquafortis.

3. The ſame would happen with the ſolution of biſmuth made with aquafortis becauſe it diſſolves likewiſe in the acid of common ſalt, except when a very great quantity of water is added, for, then the ſolution will rather unite with the common ſalt; and then it produces another curioſity, which is a kind of *ſympathetic-ink*, and is made in the following manner: Sympathetic ink

Diſſolve one part of biſmuth, or of its ore, (as commonly called) in two parts and a half of aquafortis, pour this ſolution upon one part of common ſalt, and diſtil the liquid part gently off in a glaſs retort, and the ſalt which remains in the retort is of a blue colour while warm, but when cold, turns red. Diſſolve this ſalt in a pure water, and pour the ſolution, which will be of a reddiſh colour, off from what has ſettled at the bottom, which is a white inſoluble earth, and the liquor is the ſympa-

ſympathetic ink. Or put that liquor in a retort, diſtil it off, and a reddiſh dry ſalt will remain, which muſt be kept in a phial with a grinded glaſs ſtopper, and you have the ſame ink in a dry form. For, if you will write, diſſolve but a little of it in water, and it has the ſame virtue as the above liquor. This ſolution, when made warm, turns blue, and when cold aſſumes its red colour again.

It is thus uſed: It expreſſes all the characters indeed in a red colour while you write, but this reddiſh colour diſappears as ſoon as the pen leaves them, and the paper appears perfectly white and ſmooth, but when held to the fire the letters appear in a green colour, which when cold diſappears again, and leaves the paper as white as before; and this may be repeated as often as deſired.

PROCESS LVI.

To diſſolve calcareous-earths and ſtones with ſpirit of common-ſalt, and to make therewith a fixed ſalt armoniac, and likewiſe Homberg's phoſphorus.

Method.

1. Pour upon quick-lime or upon chalk ſucceſſively as much of ſpirit of ſalt as to have it entirely ſaturated, ſo that upon a repeated addition of the

the acid in small quantities, no effervescence further ensues; dilute then the solution with twice as much water, filter it, and let it evaporate to dryness, and you will have a salt which easily liquifies in the air, and melts in the fire like wax, and is called the *fixed salt armoniac*. Fixed salt armoniac

2. Make a mixture of *salt armoniac* and *quicklime* together, put it in a cement fire, or let it melt, or distil in a retort the volatile alcali way, elixivate the remainder with water, filter the liquor and evaporate it to dryness. Or dissolve the salt armoniac in water; pour it upon quicklime, distil the volatile salt over, elixivate the remainder, filter the liquor, then evaporate, and you have always the same fixed salt armoniac. But care must be taken to add no more of the salt armoniac than the quicklime requires to its saturation, else part of the real salt armoniac would be obtained again among the elixivated salt.

3. Grind one part of salt armoniac to powder, take two parts of quicklime which has crumbled by itself to powder in the air, make of both a perfect mixture, put it in a crucible, let it melt in a gentle heat, which it will do as soon as the crucible begins to be red-hot. Stir it often with an iron rod, else it will run over during the fusion. When it is in perfect fusion, immerge several little bars of iron or copper, and the matter will stick fast to the metal when cold; or pour the fused matter out in any vessel of copper. If you then strike those pieces which have been immerged, or the mixture which has been poured out, with a hammer or any hard substance, every part touched by the

ſympathetic ink. Or put that liqu[illegible] tort, diſtil it off, and a reddiſh d[illegible] remain, which muſt be kept in a[illegible] grinded glaſs ſtopper, and you [illegible] ink in a dry form. For, if [illegible] diſſolve but a little of it in [illegible] the ſame virtue as the ab[illegible] ſolution, when made war[illegible] when cold aſſumes its re[illegible]

It is thus uſed: It expr[illegible] [illegible]me- indeed in a red colo[illegible] [illegible]nt in the this reddiſh colour [illegible] [illegible]s earths and pen leaves them [illegible] [illegible] alcali contained perfectly white an[illegible] [illegible]eparated and driven the fire the lette[illegible] And this is the reaſon which when col[illegible] [illegible]ect is obtained when you the paper as w[illegible] [illegible]eous earth with the ſpirit of repeated as o[illegible] [illegible]ready made, or ſtill contained [illegible]rmoniac: Or, when you mix the [illegible]iac either dry, or diſſolved in water, [illegible]e calcareous earth, and give it then its

P[illegible] [illegible]per heat; except if you deſire to collect

To diſſo[illegible] and to keep the volatile alcali for other pur- with ſ[illegible] poſes, for then it is beſt to diſſolve the ſalt there[illegible] armoniac in water, and pour it upon the wiſe[illegible] calcareous earth.

ce[illegible]
t[illegible]

PROCESS

E S S LVII.

... arsenic, regu-
... smuth, with

... common spirit ... colour first into ... nish colour, and col- ... bottom. Then pour it ... and the same spirit upon ... or lamina, and it will turn ... and greenish afterwards, and ... white calx at the bottom.

Solutions with spirit of common salt.

... d *zinc* dissolve by far more readily, ... a strong ebullition, in this spirit; and ... e metals leave during the solution some ... sediment at the bottom undissolved; yet ... n pouring fresh spirit upon this black remain- ... er, it dissolves readily. The solution of *iron* is at first of a deep yellow, but when entirely saturated, turns into a greenish, which being made warm, assumes a brown colour. But the solution of *zinc* remains unchanged without any other colour.

3. Pour upon filings of *tin*, or *tin-chips* from the pewterer's, a good spirit of common-salt, and it will make a yellow solution. But *bismuth* must be set warm with the spirit of common salt, and

ſtroke, will inſtantly appear like pure fire. This is called *Homberg's phoſphorus.* If you will keep thoſe pieces, it muſt be in a warm or dry place, becauſe this compound will eaſily liquify in the air.

Hom-berg's Phoſpho-rus.

Obſervation.

Salt armoniac conſiſts of a volatile alcali and of the ſpirit of common ſalt. Since then this ſpirit unites much readier with a calcareous earth than with the volatile alcali, it immediately leaves off this when brought in the heat, unites with the calcareous earths and diſſolves it, while the volatile alcali contained in the mixture is entirely ſeparated and driven out by the ſame heat. And this is the reaſon why the very ſame effect is obtained when you diſſolve the calcareous earth with the ſpirit of common ſalt already made, or ſtill contained in the ſalt armoniac: Or, when you mix the ſalt armoniac either dry, or diſſolved in water, with the calcareous earth, and give it then its proper heat; except if you deſire to collect and to keep the volatile alcali for other purpoſes, for then it is beſt to diſſolve the ſalt armoniac in water, and pour it upon the calcareous earth.

PROCESS

PROCESS LVII.

To dissolve copper, iron, tin, arsenic, regulus of antimony, zinc, bismuth, with spirit of common salt.

Method.

1. Pour upon lamina of *copper* a common spirit of salt, and it will change its colour first into brown, but at last into a greenish colour, and collect a white powder at the bottom. Then pour it off from this white calx, and the same spirit upon other copper filings or lamina, and it will turn again brown at first, and greenish afterwards, and settle as before a white calx at the bottom. Solutions with spirit of common salt.

2 *Iron* and *zinc* dissolve by far more readily, and with a strong ebullition, in this spirit; and both these metals leave during the solution some black sediment at the bottom undissolved; yet upon pouring fresh spirit upon this black remainder, it dissolves readily. The solution of *iron* is at first of a deep yellow, but when entirely saturated, turns into a greenish, which being made warm, assumes a brown colour. But the solution of zinc remains unchanged without any other colour.

3. Pour upon filings of *tin*, or *tin-chips* from the pewterer's, a good spirit of common-salt, and it will make a yellow solution. But *bismuth* must be set warm with the spirit of common salt, and

the solution will be of a yellow reddish colour. *Regulus of antimony* grows hot in that spirit, when it is very good and strong, yet does not dissolve, but only corrodes in a white powder. *Arsenic*, or rather the *regulus of arsenic*, must be brought to boil with the spirit, and then a white, light powder appears swimming on the surface, so that only part of the arsenic is dissolved by that spirit.

Observation.

1. The white powder which is produced by the solution of *copper*, has induced many to think that it is silver, or a substance which might be changed into that metal when mixed or melted with other fine silver: which they have concluded from the resemblance it bears with the white calx of silver, and from that the silver does not dissolve in spirit of common salt. Yet it is notwithstanding no more than a real copper calx, and its precipitating in that form arises from an admixture of the vitriolic acid, which has introduced itself among the spirit of common salt by the distillation when first made. For, if some real oil of vitriol is added to the spirit of common salt, and poured upon copper, a great quantity of the same white powder will be obtained, which for the most part will even dissolve in water; and when afterwards evaporated to a proper consistence, assumes a blue colour, which, when crystallised makes a copper vitriol. The remainder of the powder which will not dissolve in water may be reduced into copper again upon being melted with a proper phlogiston.

2. The

2. The ſolution of *iron* when left ſtanding for ſome time, depoſits by itſelf a large portion of calx, which when melted with glaſs, gives it a red colour. But if the ſolution is evaporated to dryneſs, a kind of green vitriol is obtained, which however liquifies in the air.

3. *Gold*, *ſilver*, *lead*, and *mercury* do not diſſolve in ſpirit of common ſalt alone. For, though this ſpirit unites with horn-ſilver, horn-lead, and with ſublimed mercury, this combination is merely produced by the ſpirit of nitre contained in thoſe metallic compounds when in that ſtate. For even when ſilver is entangled with arſenic, the ſpirit of common ſalt will unite with the ſilver, and diſſolve it; which may be ſeen by the red ſilver-ore when that ſpirit is poured upon it, and kept for ſome time in a warm place.

PROCESS LVIII.

To precipitate thoſe bodies which have been diſſolved in ſpirit of common ſalt.

Method.

Put a piece of copper in the ſolution of tin, iron in that of copper, and zinc in the ſolution of iron, and the diſſolved metal will precipitate. But in general all bodies diſſolved in ſpirit of common ſalt may be precipitated with an alcaline ſalt, except zinc, becauſe the ſolution of this latter runs only together into a kind of jelly with the alcaline lye.

PROCESS

PROCESS LIX.

To dissolve calcareous earths and stones with aquaregis.

Method.

Solutions with aquaregis.

Pour *aquaregis* upon *chalk* or *quicklime* successively as much and often 'till it effervesces no more; filter the liquor, and let it evaporate to dryness; and from the quicklime you will have a *fixed salt armoniac*; and from the *chalk* a salt which constitutes partly the ingredient of *Balduin's phosphorus*.

Observation.

Since the aquaregis is made up of aquafortis and spirit of common salt, (§. 255) and as each of these acids dissolve equally the calcareous earths and stones, it cannot fail but the aquaregis must have the same effect upon these bodies. And although these two acids are here united together, yet none of them have been destroyed by their union, but each has retained its first property and power, which may be proved by dissolving a fixed alcaline salt therein: For, upon evaporating and crystallising this solution, partly a regenerated saltpetre, partly a regenerated common salt will be obtained. Consequently, when quicklime has been dissolved in aquaregis, partly a fixed salt armoniac, (Process LVI.) and when chalk, part of the ingredient to Balduin's phosphorus must be obtained, (Process L.)

PROCESS

PROCESS LX.

To diſſolve gold in aquaregis, and to make therewith a precipitate, called *aurum fulminans*.

Method.

1. Pour five parts of aquaregis upon one part of gold beaten into thin lamina; keep it conſtantly in an equal, gentle heat, yet by no means boiling. When all is diſſolved, put ſome few more of gold into it, 'till at laſt ſome part of the metal remains undiſſolved at the bottom. In caſe ſome ſilver has been among the gold, it remains at the bottom in a black powder. The ſolution is of a deep yellow colour. Solution of gold.

2. Put ſome drops of oil of tartar in the ſolution, 'till the yellow colour of the liquor has changed into a limpid one, and the gold falls down in a fine powder. Edulcorate this powder, and dry it very gently with the utmoſt precaution, only in a warm room upon a paper, without bringing it near the fire, nor even in the ſun: and this powder is the *aurum fulminans*, which in the leaſt degree of heat fulminates with great violence and a loud report, and diſſipates in the minuteſt particles. Aurum fulminans

Obſervation.

1. If too much of the fixed alcali is poured into the ſolution, the calx loſes its fulminating power. The ſame aurum fulminans may be made

made indeed with a volatile alcali, but then the leaſt quantity exceeding the exact proportion, diſſolves the precipitated calx again. (See Proceſs XXXVI.) If this gold powder is brought to diſcharge underneath a large campana of glaſs, all the gold, after the ſtroke is gone off, will be found again in its metalline form, but in very minute particles. This powder may be deprived entirely of its fulminating property, by mixing it only, but very carefully, with powdered ſulphur; for then it may ſafely be brought in the fire to fuſe, and the ſulphur will burn away. For, this powder ſeems to acquire this property in ſome meaſure from a volatile ſalt, which is either contained already in the aquaregis, or has been employed by the precipitation. This reaſon acquires the more probability from hence, viz. in caſe this powder has loſt its fulminating power by adding too much of the fixed alcali to the ſolution, it will recover that quality only upon being moiſtened for ſeveral times with a volatile alcali. Moreover, as the aquaregis contains a ſpirit of nitre, which together with the volatile alcali, conſtitutes an inflammable ſalt-petre, it is probable that the fulminating quality may likewiſe derive in a great meaſure from that circumſtance. But as the vitriolic acid of the ſulphur diſſolves much readier the alcaline than the acid part of the nitre, this vitriolic acid upon being burned with the gold powder, unites with the volatile alcali, and therewith the inflammable ſaltpetre is not only deſtroyed, but entirely expelled by the fire. And from this reaſon this powder

may

may be deprived of its fulminating power even by oil of vitriol alone.

4. If some rags of fine linen are immersed in this solution of gold, then made dry and burnt to tinder, you will have a powder with which the silver may instantly be gilded, only by rubbing this metal with a wetted cork dipped in the powder. This is called the *gilding without fire*; but it wastes more of the gold than the gilding with mercury.

PROCESS LXI.

To precipitate the gold dissolved in the preceding process, with copper-vitriol, or with verdigris.

Method.

Dissolve the vitriol in water, and the verdigris in vinegar, filter either of the solution through a paper, pour it in the solution of gold, then dilute it with more water, let it stand 'till all has settled, and the gold powder will appear in its metalline form so bright and pure, that even with antimony it may not be made finer; and when melted, proves perfectly soft and malleable, provided it hath been well edulcorated, and no kind of impurity brought to it by the water or vinegar, &c. One part of gold requires about eight parts of the copper-vitriol to this precipitation.

To precipitate the gold.

Observation.

Observation.

1. In this operation, the gold is precipitated by two reasons. First, because neither the acid of vitriol, nor that of the vinegar, can affect the gold; therefore the aquaregis being destroyed by these acids, the particles of gold are disengaged, and fall down in a powder or calx. Secondly, because aquaregis dissolves copper far more readily than gold; therefore the aquaregis takes instantly hold of the copper contained in the verdigris, and so disengages the gold likewise to fall down by itself.

2. Gold may likewise be precipitated into a brown calx, with adding a solution of mercury made with aquafortis; but this precipitation is more troublesome, more expensive, and not so pure as the former; because part of the mercury, which by itself is a powerful menstruum for dissolving the gold, unites itself with the gold, and must therefore be again expelled from it by fire. So may likewise the gold be precipitated with iron; but as the iron leaves always some of its substance in a black powder when dissolved in an acid, this part of iron mixes with the gold, and renders likewise it impure.

PROCESS

PROCESS LXII.

To dissolve tin in aquaregis, and to precipitate with this solution the gold into a purple, or ruby-red calx.

Method.

1. Make an aquaregis of two or three parts of aquafortis, and of one part of common salt, put some small pieces of tin into it, yet by such intervals, and in so small parts that the solution may go very slowly without growing warm, or emitting any fumes; and the tin will for the most part dissolve, and leave but a little black powder at the bottom. When it will dissolve no more, pour the solution off clear and without any of the sediment; let no tin remain too long in this solution, because it is apt to collect a slimy earth or calx at the bottom. When the clear solution has stood by itself for about twelve hours, throw another little piece of tin into it, and then the solution will sometimes acquire a fine columbine colour. Tin with gold.

2. Dilute this solution with a great quantity of water, for example, with a hundred parts; stir it well with a glass pipe or wood, take out some of that liquor in two small phials; into one of them pour some more water, and stir it again; then let in each phial fall one drop of the gold solution, and that which proves of the finest red will be the right proportion; after which you may dilute the

ved

rest of the tin solution. The gold must be dissolved in an aquaregis made of three parts of aquafortis, and of one part of spirit of common salt. Of the tin solution commonly two parts are taken to one of the gold solution, in this operation. When you have found the right quantity of water which is to be added to the tin solution, you may then pour the gold solution in at once, and stir it well together, and the liquor will immediately turn red; and when it has stood for some hours quiet, then you may put in a few drops more of the tin solution, for this will precipitate all the remaining gold out of the liquor. In about twelve hours the solution will appear clear, and all the red calx has settled at the bottom in a fine powder, from which you must pour off the water, and edulcorate the powder with clean water; collect, dry, and keep it, for it serves to make the ruby glass, and the purple enamel upon china-ware.

Ruby calx of gold.

Observation.

1. By dissolving the tin, care must be taken that the solution may not heat in the least, or raise any red or yellow fumes: for so soon as this happens, the solution is no more fit for this purpose. From this it will appear that these yellow or red fumes should make one of the chief ingredients to produce that beautiful red tinge with the gold solution, and to precipitate it in a calx of the same colour.

2. By this means gold may readily be discovered in any metallic or mineral body, though it may

may contain but the minutest part of that noble metal.

PROCESS LXIII.

To dissolve copper, iron, lead, bismuth, arsenic, regulus of antimony, zinc, and cobalt with aquaregis.

Method.

Bismuth, *arsenic*, and *regulus of antimony* must be set warm with the aquaregis, but the other metals will dissolve cold. *Lead* dissolves indeed better with aquaregis than with the spirit of common salt, yet the solution is not clear.

Observation.

Since aquaregis is made up of aquafortis and spirit of common salt, it is natural that those metals which will dissolve even in the aquafortis, or in the spirit of common salt alone, such as copper, iron, and zinc, must likewise dissolve in aquaregis. But it is difficult to explain why gold may be dissolved with the aquaregis, though it is not affected either with aquafortis or with spirit of common salt when each by itself.

PROCESS LXIV.

To diſſolve mercury with aquaregis and to make therewith ſublimed mercury.

First Method.

Mercury ſublimed. Diſſolve half a pound weight of mercury in three quarters of a pound of aquafortis, let the ſolution evaporate to dryneſs. Take ten ounces of decrepitated common ſalt, and as much vitriol dried or calcined in a warm place into a white powder, grind each by itſelf in a mortar of glaſs or marble, then mix both very well together, and at laſt mix the white powder of mercury to it. Put this mixture in an alembic of glaſs, ſo that but a third of its belly may be filled up with it, and the neck of the glaſs be cut off ſo as to remain but ſeven inches high. Put the alembic in a ſand coppel, let the ſand reach juſt as far as to be equal with the mixture contained in the glaſs, give firſt a ſlow fire, increaſe it by degrees, till the vapours riſe, which are very poiſonous. When no more moiſt damps appear, ſtop the glaſs only with a paper, then increaſe the heat ſo as to make the ſand-coppel red hot, and with that the mercury will ſublime and collect on the ſides round the veſſel; when all is cool, break the veſſel, ſeparate carefully the ſublimed mercury from the other light mellow powder, and keep it dry in a cloſed veſſel.

Second

Second Method.

Diſſolve the mercury in a cucurbit with a ſufficient quantity of aquafortis, put afterwards one part and a half of common ſalt ſucceſſively in the ſolution, apply a helmet to the glaſs, diſtil all the fluid part over with a gentle heat; when dry, increaſe the fire and proceed with the reſt as above directed.

Obſervation.

1. By the firſt method an aquaregis was produced, becauſe the vitriolic acid unites with the alcaline part of the common ſalt, and frees therewith its ſpirit ſo that it unites with the aquafortis. In the ſecond method, part of the aquafortis takes hold of the alcaline part of the common ſalt, and frees therewith likewiſe its ſpirit, ſo as to unite with the remainder of the aquafortis, and conſequently makes likewiſe an aquaregis. Now, though mercury diſſolves but difficulty in aquaregis, yet it ſucceeds here by the aſſiſtance of heat, by which the aquaregis is deprived of moſt of its aquatic parts, and conſequently much concentrated. The ſubſtance obtained is properly nothing more than a vitriol of mercury, but it differs from the other made with aquafortis, chiefly that it is ſémivolatile, whereas that made in this proceſs proves more fixed in the fire. It is the ſtrongeſt corroſive cauſtic in nature, becauſe it corrodes and eates away every part of animal ſubſtance wherever it touches,

touches, whence being the ſtrongeſt poiſon it muſt be uſed with the utmoſt circumſpection; And ſince two grains are ſufficient to kill any living creature, mouth and noſe muſt be bound up with a handkerchief by the grinding and pounding, in order to avoid the duſt which may ariſe up. Its effects upon metals are very peculiar.

Mercury dulcis.

2. If to this ſublimed mercury, about the ſame quantity of freſh live quickſilver is added, by grinding both together till they unite into a grey powder, and then this mixture is brought to ſublime again, a new compound is obtained which is called *mercurius dulcis*, which muſt be quite taſtleſs, otherwiſe it muſt be ſublimed once more with adding again ſome of the live mercury. The effect of this, though ſtill very ſtrong, is by far not ſo powerful than that of the ſublimed mercury; whence it is uſed with ſucceſs in phyſic if applied with proper caution.

PROCESS LXV.

To precipitate thoſe bodies which have been diſſolved in aquaregis.

Method.

1. Proceed after the ſame method as given in Proceſs LV. The ſublimed mercury muſt be diſ- ſolved

ſolved in water, then a fixed alcali brought in by drops, and the mercury precipitates in a red powder, which will prove the finer and deeper in colour, the purer and ſtronger the fixed alcali has been. Hence the ſtrength and goodneſs of any fixed alcali may be diſcovered by that method, viz. to rub it with ſome of this ſublimate in a little mortar, when it changes immediately the mixture into a moſt lively deep red colour. **The red precipitate of mercury**

2 If you deſire to reduce the ſublimed mercury into its firſt live form again, and to make at the ſame time the *butyrum antimonii*, add and mix the ſame quantity of crude antimony finely powdered with the ſublimed mercury, put this mixture, when dry, in a retort, apply a receiver, ſecure the joints with a paſte of quicklime and clay, diſtil carefully and by degrees, and a greaſy matter will riſe over which congeals in a kind of jelly or butter in the receiver, and collects in the ſame form within the neck of the retort, from whence it may be melted down with holding lighted coals to the place, which makes it run down in the receiver like butter. If nothing more will riſe over in that degree of heat, take the receiver off, apply another, and then increaſe the fire for ſome hours to the utmoſt ſtrength, and a ſubſtance of various colours riſes and ſome mercury in its live and current form comes over in the receiver, together with the remainder of an impure butter of antimony. If the retort is afterwards broke, you find the cinnabar of antimony ſticking in the upper part next to the neck. **butyrum antimonii** **Cinnabar of antimony**

Observation.

1. In this operation the greatest care must be taken by grinding and mixing these substances as well as in case any fumes should penetrate through the joints of the vessels, in order to avoid in the first the dust, in the second the fumes, as being the most dangerous poison.

2. Aquaregis unites much more readily with the regulus of antimony than with mercury, therefore it leaves here the sublimed mercury, takes hold of the reguline part of the antimony and changes itself into a semivolatile vitriol of antimony, which has the name of *butter*. This semivolatile substance being gone over, then only the sulphureous part of the antimony together with the mercury remains behind in the retort, which two dissolving one another, are at last with a stronger fire sublimed into the form of cinnabar.

3. If instead of crude antimony, the regulus of it is mixed with sublimed mercury, then you will obtain a clean butter of antimony, and all the mercury in its live form, without any cinnabar.*

* Because the antimony has here been added without its sulphureous part, and therefore the mercury rises all over in its live form: Whereas by the other method, where antimony is taken crude, the mercury unites with the sulphur of the antimony and remains mostly behind in the form of cinnabar, consequently but a small part of it is obtained in its live form.

PROCESS

PROCESS LXVI.

To dissolve copper and iron with salt armoniac in the liquid way.

Method.

Dissolve the salt armoniac in warm water, and boil file-dust of iron or of copper in this liquor for some hours, filter it, and part of the metal will be dissolved: The solution of copper proves of a styptic nauseous taste and of a bluish green, and that of the iron, of an astringent taste and a reddish brown colour.

Observation.

Since salt armoniac consists of the spirit of common salt and of a volatile alcali, and as copper will as readily as the iron dissolve in either of these two menstrua, these metals are in this operation dissolved from a two fold cause. By the same method other metals may likewise be dissolved in case they are affected either by one or both these menstrua. For, notwithstanding the spirit of common salt unites indeed better with the volatile alcali than with the metals, and therefore the metals, when dissolved in the spirit of common salt, may be precipitated with the volatile alcali; yet the volatile alcali is in this operation too soon expelled by the motion of the heat and boiling, so as to fly off along with the steam of the boiling water before it has time to dissolve the metals and to acquire any degree of fixity by that combination.

PROCESS LXVII.

To diſſolve iron with ſalt armoniac in the dry way, and to ſublime therewith part of the metal.

Method.

Rub equal parts of freſh clean iron filings and of ſalt armoniac together in a glaſs-mortar, the longer the better; and a volatile alcaline ſteam will riſe even during the trituration. Put this mixture in a pretty large glaſs cucurbit with a wide neck and mouth, ſo that the matter may have full room, apply a head upon the veſſel, and a receiver to it, ſecure the joints with paſte, order the veſſel in a ſand coppel and fill it up with ſand till to the border of the head. Give firſt a gentle heat, and a very volatile alcaline liquor will go over. When nothing more riſes in this degree of heat, increaſe it ſo much that the head may grow warm, and then ſome white vapours will begin to riſe up at firſt, but at laſt the inſide of the head will all be filled with red, yellow, green, and blackiſh colours, like artificial flowers, whence they have the name of flowers. Let the ſame degree of heat continue for ſix or eight hours, and then let it go out and cool by itſelf. When cold, you will find in the receiver a very ſharp alcaline liquor of a gold yellow colour; in the head and its neck, a very tender, dry, beautiful and variouſly coloured matter, which inſtantly muſt be put in a warmed dry phial and well ſtopped, becauſe it ſoon attracts moiſture, and then

Iron flowers

it

it would turn into a ſaltiſh, acerb, gold-yellow, and fattiſh juice. In its dry ſtate, it has the name of *iron-flowers*, but when liquified, it is called liquified *oil of iron* At the ſides within the cucurbit, a like ſort of ſuch flowers will be found collected towards the neck, yet they appear more ſolid and compact, as if melted together. Thoſe muſt be taken out with the ſame care and kept likewiſe in a cloſe veſſel. At the bottom of the veſſel lays a brown-red ſubſtance, which proves of a very acerb taſte, and ſoon liquifies in the air, into a thick, aſtringent, gold-yellow juice, which at laſt, after a yellow powder has ſettled at the bottom, turns greeniſh, and is called the *ſecond liquified metallic oil.* During the ſolution of this ſubſtance in the air, it foams much up, ſo that a ſtrong fermentation ſeems to proceed by this ſolution.* Oil of iron.

Obſervation.

1. The ſpirit of commmon ſalt (contained in the ſalt armoniac) begins even during the trituration to act upon the iron, ſo that part of the volatile alcaline ſpirit is already carried off and ſeparated from the acid part. But one part of the ſalt armoniac remains unchanged with the iron, and takes then in the operation that ſame part of the iron up to ſublime, which had been diſſolved by the ſpirit of common ſalt.

* The cauſe of this fermentation muſt be the acid in the air, which this highly alcaline matter attracts with great rapidity.

2. In the same manner other metals may partly be sublimed and divided in the most minute parts by means of salt armoniac: Whence this mineral has been given various names by the alchymists, such as the preying vultur, the white eagle, and the key to open the metals.

PROCESS LXVIII.

To dissolve copper, iron, tin, lead, zinc, bismuth, regulus of arsenic and of antimony, with salt-petre, in fusion.

Method.

Reduce the metal with pounding, filing, or granulating, into small pieces, mix it with as much pure dry salt-petre in powder, put the mixture in a red-hot crucible, and the salt-petre will detonate as with a phlogiston, and destroy part of the metal.

Observation.

1. Salt-petre inflames with the phlogistic part of the metal, and carries part of it up with itself. And since by this means one part of the salt-petre is become a fixed alcali, this will not only dissolve that portion of the metal which has been deprived of its own phlogiston during the deflagration, but even that part of the remaining metal which had suffered no change. (See Process XXVIII.)

2 From

2. From hence we may see that it is very improper to assay ores upon any of these metals with unprepared fluxes, because the crude salt-petre will destroy a great part of it; besides that by so violent a detonation the whole assay must be rendered uncertain and defective.

3. Gold and silver cannot be affected nor destroyed by salt-petre, consequently they may therewith be parted and cleansed from the admixture of other metals. And if but a small portion of those metals is mixed with the gold or silver, this end may be obtained by throwing a little of a pure salt-petre, made warm, upon the gold and silver in fusion at a time, then a few minutes remain in fusion with the metal, then poured out, and the same repeated as often as the scoria is found of any metallic colour. But if a great part of such metals should be mixed among the gold or silver, then the salt-petre must be mixed with some borax, or a fixed alcaline-salt, in order to prevent the violent deflagration and the strong fumes of the salt-petre, as by those some part of the gold or silver would be carried off and lost, which is prevented by the said addition of the alcaline-salt. This is the principle of *exalting the gold* in colour and fineness.

To refine gold and silver with salt-petre.

Exalting the colour of gold.

PROCESS

PROCESS LXIX.

To dissolve such metals which require a strong fire to their fusion, as silver, copper, and iron, with common-salt, or with salt-petre, by *cementing*.

Method.

Cementing. 1. Pound a clean sort of bricks, such as are not too hard baked, to a fine powder, then sift it, that all sandy or stony particles may be parted. Take of this four parts, of colcothar one part, and of common salt one part, make it into a perfect mixture, and moisten it with water so much as to be made into balls. Or, take four parts of brick-dust, one part of colcothar, and one part of salt-petre. Those mixtures are called *cement*, or *cementing powder*.

Cement-powder. 2. Put some of this cement into a cementing-box, or a crucible, lay first a stratum of it about half an inch thick at the bottom, pressing it even and close with the finger; upon this lay some of the laminated metal, which must first be well cleansed by making it red-hot, and likewise an exact weight taken of the whole quantity; then lay another strata of the cementing-powder upon these lamina, pressing it smooth as before, then other lamina of the metal upon this, and so on till the box is filled up to about half an inch from the border, which last interval must be filled up with cementing powder, then a cover put on and well luted.

3. The

3. The vessel being filled up in that manner, must be put in a place where it may be kept for many hours in a continual equal heat, such as a glass-furnace, or an athanor. The heat must at first be given gently, then encreased by degrees, yet no more than to make the vessel just moderately red-hot.

4. After the vessel has been glowing red-hot for about twelve or twenty hours, let the fire go out by itself, and when cold, open the box, take out the cement, and if it should have baked too hard together, wet it a little with water, then take the lamina, as much as is left of their substance, boil them several times in clean water till the water leaves no more taste of salt, dry and weigh them, and you will find them considerably diminished in weight.

Observation.

1. Brick-dust prevents the salts from fluxing, by which means the fire can act with more effect upon the saline particles, and expel consequently the spirituous from the alcaline parts.

2. If the colcothar is not elixivated, it contains part of the vitriol, the acid of which unites here with the alcaline part of the common-salt, by which its spirit is set free from the alcaline part, and acts then upon the metal as an acid. By this method even the silver cannot resist the spirit of salt, but is dissolved by it, though in the liquid way it is never affected by that acid. If, instead of colcothar, salt-petre is taken, together with the common salt,

ſalt, the cement will then act as an aquaregis, becauſe the ſpirit of ſalt-petre unites in that caſe as well with the alcaline part of the common ſalt, as the ſpirit of common ſalt does with the alcaline part of the ſalt-petre, whereby both theſe ſpirits are brought to riſe and conſequently make an aquaregis.

Refining of gold.

3. Upon this principle depends the art of refining gold by cementing, and is made uſe of when but a ſmall portion of ſilver, of copper, or of iron is mixed among the gold; for when ſuch gold is firſt beaten into thin lamina, and proceeded with the cementing as above directed, thoſe baſe metals are all diſſolved and deſtroyed, either by the ſpirits of common ſalt, or by thoſe of the ſalt-petre, which are contained in the cementing powder and confined in the cloſed box, ſo as to act upon thoſe metals without any detriment to the gold, becauſe gold cannot be diſſolved either by ſpirit of common ſalt, or by that of ſalt-petre alone; however the operation muſt commonly be ſeveral times repeated. Only care muſt be taken that never ſalt-petre and common ſalt are brought both together in this mixture, becauſe they conſtitute an aquaregis, which conſequently would diſſolve part of the gold, and this be loſt among the cement-powder. From this a judgment may be formed of all theſe various, uſeleſs, ſuperfluous, partly expenſive, and often quite noxious mixtures found in ſeveral authors; but chiefly to guard againſt that often recommended *graduating-cement*, ſo called, by

by which they exalt the colour of gold; for this powder always contains a mixture of copper, which has been either calcined with ſulphur, or is contained therein in the ſhape of verdigris, copper-vitriol, &c. which ſubſtances being added to the cement, give indeed to the gold a deeper colour, but being nothing but copper, it ſtands no trial, neither with antimony, nor with lead, nor even with the common cement.

PROCESS LXX.

To diſſolve the acid ſpirits with oil, and to make from oil and oil of vitriol a ſulphur.

Method.

Put four ounces of a pure diſtilled oil of turpentine in a retort, drop in ſucceſſively one ounce of a pure oil of vitriol, ſhake always the retort after a few drops of the oil of vitriol have been added, in order to have it perfectly mixed. During this operation, the mixture grows warm and turns red, emitting at the ſame time fumes of different ſmell. Then keep it ſome days in a warm place, after which time order it in a ſand coppel and apply a large receiver, and a peculiar oily liquid matter raiſes over The mixture which remains in the retort has then the appearance of a melted bitumen or reſin, which grows by degrees thicker, and acquires at laſt the conſiſtence of a bitumous pitch; and the ſubſtance in the receiver proves of a ſuffocating

Artificial ſulphur of oils.

focating ſulphureous ſmell. If a proper regimen of fire has been obſerved, a real ſulphur will appear collected in the neck of the retort.

Obſervation.

1. Other ſorts of acids may likewiſe be diſſolved with oils, but as they are not ſo replete of acidous particles as the vitriolic acid, they muſt be taken in greater quantities, as may be learned from Proceſs XXXIV, where the exact proportion of the acidous and aquatic particles contained in acid ſpirits, have been given. But a real ſulphur cannot be obtained from thoſe as with the acid of vitriol.

2. From all other ſubſtances in which a vitriolic acid is contained, ſuch as tartariſed vitriol, Glauber's ſalt, common ſalt, calcined alum, &c. a real ſulphur may likewiſe be produced when they come to be united with a phlogiſton. For example, let ſome of Glauber's ſalt fuſe in a crucible, throw ſome coal-duſt into it, and a ſulphureous flame will riſe, leaving a brown red matter behind in the crucible. Diſſolve this ſubſtance in water, precipitate it with vinegar, and what falls to the bottom will be a real ſulphur. As therefore the foſſil kingdom contains ſuch an immenſe quantity of ſulphur in the marcaſitical and moſt other ores, it is plain that no ſmall quantities of oil and phlogiſton muſt be lodged in that kingdom.

Oil and phlogiſton in foſſils.

3. From hence we may explain the origin of the mineral-bitumen, mineral-pitch, ſea-coal, and

and amber; and why marcasites, vitriol, or vitriolic-waters are most frequently found along with sea-coal. The real cause is, that all these fossil bodies are chiefly produced by the vitriolic acid and a phlogiston combined together, and lodged in a proper matrix of various earths and stone kinds in different proportion and quantity.

4. Spirit of wine being nothing else but a very subtle oil, unites likewise with acids, though with some more difficulty; and from that combination we have the *dulcified spirit* of *nitre*, of *common salt*, Hoffman's *anodyne spirit*, and several the like preparations for medical purposes, which may be seen in Pharmacevtic and other chymical authors.

PROCESS LXXI.

To dissolve sulphur with expressed oils, and to make therewith the *balsam of sulphur*, so called.

Method.

Pour any expressed oil of vegetables in an earthen glazed vessel, or in a large pan, put a fourth part of flowers of Sulphur into it, bring the vessel over a gentle fire, and increase it with care. When the mixture is become so hot as to make the sulphur melt, it sinks down to the bottom, and turns into a deep red shining juice, but will not yet dissolve

Balsam of sulphur.

dissolve in that degree of heat; increase therefore the fire a little more, but with the utmost caution, because it will either take fire, or run over, if raised the least too strong or suddenly; so soon as the the oil begins to fume, then the solution goes on and discovers itself with foaming up and raising an intolerable stench, and then it turns into a dark red substance, in which afterwards more sulphur may be dissolved, when added as above at the time it begins to fume.

Observation.

1. The purer an oil is the less quantity of sulphur it dissolves; therefore with distilled oils hardly a sixteenth part of sulphur may be dissolved, and with the strongest spirit of wine none at all.

Utility of soap in assays.

2. This balsam of sulphur will unite with a fix'd alcaline-salt, and constitute therewith a peculiar kind of soap, and from this principle depends the great utility of soap in the assaying of ores and minerals. For, if any sulphur is contained in an ore, or other metallic compound, and a fixed alcaline-salt is only added as a flux, it dissolves the sulphur and by that makes a hepar-sulphuris, of which we know that it destroys every metal, even gold; and consequently no metal, or at least not the true quantity will be obtained from the ore. This inconvenience is prevented by the oil contained in soap.

PROCESS

PROCESS LXXII.

To diſſolve lead or its calx with expreſſed oils.

Method.

Put granulated lead, or lytharge, or minium, in an earthen glazed veſſel, pour twice as much common linſeed oil, or any other the like expreſſed oil upon it, give a very moderate heat and raiſe it by gentle degrees, and the lead or calx will come to fuſe before the oil boils, and when this boils, the other will be entirely diſſolved. In this ſtate it is called *lead-balſam*; if left for ſome time longer to boil, it turns into a ſtrong, compact, ſemi-metalline ſubſtance, which grows hard when cold, and melts again when hot. **Balſam of lead.**

Obſervation.

1. This very peculiar ſolution of one of the heavieſt metals, in a vegetable oil, proves how metals may be entangled with other bodies, and likewiſe how they often may be diſcovered in ſubſtances wherein they could hardly be ſuſpected. Whence one can never be too cautious againſt cheats, and their pretended tranſmutation of metals.

2. This lead or the calx of lead, diſſolved in oil, is called *lead-balſam*, and is uſed with advantage for a plaſter in open and other wounds **A plaſter of it.**

A good cement for vessels

wounds and sores, chiefly if in the preparation some soap is added. And when boiled to a certain consistence, it gives an excellent stuff for reservoirs and vessels to hold water, either with overlaying, joining, or else preparing them as occasion requires. And even a whole wall, pavement, or cistern of stone, when made hot, and covered with that compound, will hold water better than with any other cement whatsoever.

PROCESS LXXIII.

To reduce calces of metals into their metallic form by means of a phlogiston.

Method.

Reduction of metallic calces.

1. Make a clean crucible warm, rub its inside with soap; mix horn-silver with any oil or fat, put it in the crucible; when in fusion, pour it out, and you will have the silver without any loss in its pure metallic form.

2. Mix a calx of lead with as much coal-dust, not by the weight, but by measure, put it in a crucible, give first a strong fire, but lessen the heat so soon as the whole substance is come in fusion, and pour it out.

3. Calcine blend (black-jack) when before picked clean from all stony particles, and ground to powder, in a pretty strong fire, and so long 'till all

all sulphureous smell is driven out; mix it then with an eighth part of coal dust, fill with this mixture an earthen and luted retort, so that three parts of the belly may be full of it; order it in an open fire, and distil four hours long, with a strong heat, and an aquatic liquor will rise over into the receiver, which proves neither of an alcaline nor acid taste: when quite cooled, break the retort, and the zinc will be found sticking near the neck of the retort in its metallic form and substance, together with its flowers collected about the same place.

Observation.

1. In the same manner the calx of any other metal, except aurum fulminans, may be reduced into its metallic form, only that the more or less refractory the calx is, the phlogiston must be likewise of a more or less fixed kind. So the calx of tin may be reduced with tallow: but a copper calx requires coal-dust, or better the black flux, so called; which consists of the phlogistic part of tartar, and of the fixed alcaline part of salt-petre.

2. Zinc, so soon as it comes in a strong fire with a phlogiston, inflames and dissipates in fumes. Therefore when the operation is made in an open vessel, the reduction of the zinc into metals succeeds indeed for a moment, but is destroyed again in the same instant. Since therefore those experiments of reducing the zinc into a metal, have always proved fruitless, it was ever believed that zinc could not be reduced at all from its flowers, or from its calx, or from the calamine, into

into a metallic form. This end is, however, readily obtained by performing the operation in a close vessel, such as a retort, and mixing the ore, or the flowers, &c. with coal-dust, as above directed, when, as a volatile semi-metal, it will by the force of heat be driven up, and collect in the uppermost sphere of the vessel, next to the neck, as the coolest place, in a compact metallic substance, together with some of the flowers.

The phlogiston in metals questioned.

3. Horn silver may likewise be reduced without any phlogiston, by means of a fixed alcaline salt. The calx of lead, and that of antimony, will yield to the same reduction with an alcaline *earth*, such as *chalk*. Therefore that general opinion, that the calces of metals should recover their metallic form only by restoring to them that phlogiston which they are supposed to have lost, does not seem to be sufficiently grounded. For, though it may be true that the phlogiston makes perhaps a substantial ingredient of metals, yet there is hardly any phlogistic matter neither in the fixed alcaline salt, nor in chalk; and it is still more questionable if the horn silver has lost its own phlogiston at all; though it cannot be questioned that it has been united with an acid. And hence it may rather seem probable that metalline calces arise from their combination with an acid, and from having been deprived of a volatile, perhaps mercurial part. Since therefore, according to Process LXX. a phlogiston, as well as every alcaline salt and earth dissolves the acid spirits,

it is my opinion, that the reduction of metalline calces is chiefly effected by that solution of those acid particles; and that the loss of part of the reduced metal, which happens almost without exception by their reduction, is owing to that volatile or mercurial part of which the metal is deprived by the action of fire during the operation.

PROCESS LXXIV.

To reduce iron into steel by means of a phlogiston.

Method.

1. Make a powder of wood-ashes and of some other substance which is most replete with a phlogiston, such as charcoal; or animal substances, such as horn, claws, &c. burnt to a black coal in closed vessels and pounded. For example: Take of charcoal stamped into a coarse powder, or rather into small pieces, one part; of wood-ashes half a part. Or, take of coal-dust two parts, of calcined and pounded animal substances, such as claws, horn, &c. one part, of wood ashes one part, make a mixture of it, which you may call here your cementing powder. Phlogiston. Steel.

2. Take an earthen vessel of a proper height, put at first as much of this cement powder in as to lie half an inch thick, when compressed at the bottom. Chuse a good malleable iron, which suffers the hammer not only when hot, but likewise when cold;

let the bars not be too thick, and some inches shorter than the height of the cementing vessel; let the bars stand upright, and half an inch asunder each from the other, and at the same distance from the sides of the vessel. Then fill the intervals up with the powder, so as to lye half an inch thick above the bars, by which the vessel must be just full when a little compressed; and lute a cover on with a good lute.

3. Bring the vessel in a furnace in which an equal heat may be given for many hours; when the vessel is grown red hot, let it remain in that degree for six or eight hours; then take it out while in full heat, and temper instantly the bars, while red-hot, in cold water, and they will be hard and reduced into *steel*

Observation.

1. Why animal substances are commonly made use of in this operation is, because experience has proved, that they contain not only a greater quantity, but in the same time a much tenderer phlogiston, which acts far quicker and better upon the iron than that of the vegetable kingdom.

2. By the preparing of the cement-powder care must be taken to avoid every kind of such ingredients which contain any mineral sulphur, or even any sulphureous acid; because this makes with the phlogiston a real sulphur. (See *Process* LXX.) For, this sulphur would

not

not only change your fine bar-iron quite into a coarse and raw kind of cast-iron, but if much of the sulphur is contained in the mixture, reduce it even into a scoria.

3. In order to know if your iron has been changed into a good steel, temper a piece of it when red-hot in cold water, and it must turn so brittle as to fly under the hammer in pieces; and likewise resist the hardest file: but when heated and cooled by itself by degrees, then it may be somewhat touched by the file, and bear the hammer in some degree. By these characteristics steel may always be distinguished from cast-iron as well as from bar-iron. For, tho' bar-iron when heated and quenched in cold water, will likewise grow hard, yet it suffers still the hammer when cold, without flying. But cast-iron remains always coarse and brittle, it may be hot or cold, tempered or not. The hotter the steel is when tempered, and the colder the water, the greater hardness it will acquire. Steel again differs from iron not only in colour, but in its texture; for steel is of a darker colour than iron, and when broke, the grain and strya is of a much smaller and finer texture than that of iron; (hence the appellation of *steel-grained.*) This will appear very plain in that case when very thick iron-bars have been cemented; because then the phlogiston was not able to penetrate through the whole substance, but only the outsides will be converted into steel; therefore when broke, the iron within appears plainly by its coarse Trial of steel.

 grain

grain and different colour from the outsides, which are finer and darker. The same difference may be discovered when iron and steel have been forged together into one piece; for when those pieces are beaten smooth with the hammer, and then tempered, the different veins will clearly appear to the eye; those of the iron being white and shining, and the other of a much darker water-colour. Hence it is thought the celebrated *Damascene-steel* is made in that manner, viz. by forging iron and steel together under the hammer, in various directions.

Damascene steel.

PROCESS LXXV.

To dissolve metals and semi-metals with sulphur, except gold and zinc.

Method.

Sulphur with metals.

1. Those metals which require a strong fire to their fusion, may only grow red-hot in a crucible, but the other which will melt in a little heat, must be brought to fuse; throw upon either of them one or two parts of sulphur in small lumps in the crucible to the heated or fluxing metal; stir it, and let it well melt together; when the sulphur has burnt away, and you see but a little blue flame remaining to play upon the melted mixture, you may conclude that the solution is performed. Iron may only be made red-hot and a lump of sulphur held to it, and it will immediately run down in a spun-

spungeous scoria; whence we learn that by sulphur, iron is rendered far more fusible than it is by itself.

2. Three parts of a testaceous cobalt being mixed with one part of sulphur, and sublimed in a proper vessel, make *orpiment*. With arsenic.

Observation.

1. As ores are a compound of metals and sulphur or arsenic, or of both together, some have endeavoured to imitate such compounds by means of an artificial solution; but this attempt has not as yet been brought to a great degree of perfection. Among many reasons, one may be this, that ores have not yet been sufficiently decomposed and divided into their component parts; and that often they may contain, besides the metals, an unmetallic earth. Such *artificial ores* as are known at our time, are *glass-ore*, (*vitreous silver-ore*,) a kind of *lead-ore*, *antimony*, *cinnabar*, *pyrite*, (called *mispickel*.) Artificial ores.

2. Crystalline arsenic will hardly dissolve with the sulphur; it succeeds better with the flowers of arsenic: but when both the sulphur and the arsenic are contained together in an ore, they unite and dissolve one another very readily, and then an orpiment and red arsenic, called *ruby arsenic*, is obtained.

3. Silver, copper, iron, are rendered more fusible by the sulphur, but tin and lead become

come refractory with it. Tin may all be reduced into scorias by degrees, when sulphur is added successively in little quantities. Regulus of antimony unites difficulty with sulphur, yet it succeeds at last, by stirring the mixture continually during the fusion. The mixture looks, when cold, pretty much like a crude striated antimony. Bismuth proves as difficult to unite with sulphur, as the regulus of antimony, and rather more so. The mixture obtained from bismuth and sulphur has very much the appearance of a crude antimony, and when exposed for some time to the open air, is covered with a stain of various colours, like a rainbow. Cobalt may likewise be dissolved by sulphur, but rather difficultly; and then it obtains a yellowish colour, resembling a kind of ore found near Freyberg, which commonly but falsely has given the name of cobalt.

PROCESS LXXVI.

To precipitate those metals which have been dissolved with sulphur, and to free them from the sulphur.

Method.

Precipitation by fusion.

1. Let one part of the silver grow red hot in a crucible, throw two parts of antimony, either native or artificial, into it; let it fuse well together, pour it into an iron cone made warm, and rubbed out

out with tallow or wax; when cold, take it out, break the ſcoria from the regulus, and this will contain nothing elſe but the ſemi-metalline part of the antimony, that is, its regulus; but the ſcoria will conſiſt of all your ſilver, together with the ſulphur.

2. Bring thoſe ſcoria to melt again with half as much granulated lead; pour it out, and then your ſilver will be contained in the regulus, but the lead in the ſcoria.

3. Take theſe ſcoria in a crucible, add half as much tin, and part of the lead will be in the regulus, but the tin, with the remainder of the lead, in the ſcoria.

4. Thoſe ſcoria bring upon half as much copper-lamina when they are grown red-hot in the crucible, let it fuſe perfectly well, then pour it out, and the tin and lead will be in the regulus, and all the copper in the ſcoria.

5. Weigh theſe copper-ſcoria, take half their weight of ſmall pieces of iron, for example, nails; let them grow red-hot in the crucible, then throw all the copper-ſcoria in; let it melt together, then pour it out, and the regulus will be copper, but the ſcoria contains the iron diſſolved by the ſulphur.

6. Grind orpiment to a fine powder, ſprinkle ſome live quickſilver into it, then grind it again, and the mercury will ſoon diſappear, unite with the powder, and render its red colour darker and dull. Repeat the ſame with adding ſome more mercury, and Cinnabar

and incorporating it with the arſenical powder, 'till no more mercury will unite with it, and the powder is quite changed into a greeniſh or blackiſh colour. Sublime this powder in a cucurbit, and you will find white or aſh-coloured flowers, together with ſome cryſtalline arſenic towards the neck of the glaſs, and lower down the cinnabar, which, however, is as yet ſtained with ſome part of arſenic.

Obſervation.

1. This precipitation or ſolution muſt not be imagined to ſucceed quite ſo exactly in this proceſs; for ſome part of that metal which has precipitated the other, will always mix with the precipitated; and ſo will likewiſe and frequently remain ſome of the latter amongſt the ſcoria. However, with the iron this ſeparation is, from a ſulphureous mixture, much better and more completely obtained; becauſe iron alone ſwallows up all the ſulphur contained in the mixture. The ſcoria will be found more or leſs fuſible according to the nature of the metal which has been employed for precipitating the other; that is, according as that metal becomes either fuſible or refractory with the ſulphur.

Parting in fuſion.

2. Upon this principle depends the *art of parting metals in the dry way*, or *in fuſion*, as it is called; that is, to free a ſulphureous mixture of one or ſeveral metals, from the ſulphur, either by means of another metal, or by the aſſiſtance of ſuch an ingredient which diſſolves the ſulphur more readily than the metals contained therein. Likewiſe when a compound of two or more

more metals, containing no sulphur, shall be separated and parted by means of sulphur. Of the first kind is the *rough-melting*, so called in the smelting-houses, and is done either partly and chiefly, or entirely and solely, by the assistance of pyritical-ores. For the iron contained in these pyrite will be dissolved by the very sulphur of the same ore, and reduced thereby, together with the metalline earth, into a fusible scoria, out of which, consequently, all other metals, they may be gold, silver, copper, or lead, will sink down and collect at the bottom by their own gravity into a regulus; though in this first fusion they retain still a portion of iron, of sulphur, and of the unmetallic earth, and therefore present themselves as yet in a raw and imperfect form, whence this mixture or regulus is called by the Germans *rough-stone*. This operation is of the utmost utility in the art of melting ores in great quantities, because by that means the smallest portion of the precious as well as of other useful metals may be collected from a great quantity of poor ores, and reduced into the small compass of a regulus, out of which each may be then separated with profit, which otherwise could not have been done. From hence it appears, that if those pyritical-ores be entirely deprived of the sulphur by roasting, they could be of no service at all, but would rather become a hindrance in this rough-melting; because the sulphur, as the dissolving agent of the iron and of the unmetallic earth, being driven out by the roasting, they would make now a very refractory and stubborn

Rough stone.

born mixture in the fire, and render the operation quite impracticable. However, upon considering this process more exactly, it will likewise appear that in some cases it will not be improper to give those pyritical ores at least a gentle roasting before they are brought to the rough melting. For, iron dissolves but a certain part of the sulphur; if therefore a great deal more of sulphur should be contained in the mixture, than the iron is able to dissolve, the superfluous sulphur remains then among and mixes with the precipitated metals, increases therefore the bulk of the mixture, and renders it lighter, and by that means apt to diffuse and unite with the scoria instead of precipitating and collecting into a regulus. Whereas when only that superfluous part of the sulphur is driven out by a gentle roasting, the metalline parts will then be brought in a lesser bulk, make less rough stone, and consequently a great deal of expence and labour be saved.

To this place further belongs the parting of the regulus of antimony from its sulphur by means of iron; and in general the precipitation of metals from sulphureous mixtures, either natural or artificial. For example:— Of silver from glass-ore, (vitreous silver-ore) and of lead from its own ore, by means of iron: the method of which is thus. Take four parts of iron reduced into small pieces, make them red-hot in a crucible; put either nine parts of the common potters lead-ore, (*bley-glanz*) pounded only in a coarse powder, or

or six or seven parts of the vitreous silver-ore, into it; let it melt well together, pour it out, and you will have in the first case all the lead, in the other all the silver, collected each by itself, pure from its ore.

To the other method, by which several metals may be separated by means of sulphur, belongs the art of *parting gold from silver in fusion*. For, here the silver is dissolved by the sulphur, and reduced into a scoria very similar in appearance to a vitreous ore, but the gold which cannot be affected by sulphur, falls to the bottom in a regulus, pure and by itself. This separation is in such cases of very great utility, when in a large quantity of silver but a small part of gold is contained, so that in great quantities it would not pay the expence of aquafortis. So is likewise the *fusion of gold through antimony* nothing else but a parting of other metals from the gold, as being performed by the dissolving power of the sulphur contained in the antimony; and the antimony is here chosen instead of common sulphur, only and chiefly because the sulphur contained in this semi-metal is of a greater fixity, as being united with its semi-metalline particles, than the common sulphur. The reguline part of antimony which falls down and mixes with the gold, may afterwards easily be driven out by fire. **Parting gold from the silver.**

3. If therefore a mixture of several metals shall be separated one from another, by means of sulphur only, it must, with respect to the order

order of solution shewn in this Process, be done in the reverse way, that is; suppose you have a mixture of iron, copper, lead, silver, and regulus of antimony, in one lump together, let the whole compound melt in a crucible, when in fusion, throw some sulphur in, and after it has melted for a while, pour it out, separate the scoria with a hammer from the regulus, and they will contain the iron, but all the other metals will be collected in the regulus, in case you have added no more sulphur than the iron did require to its solution. Let this regulus melt again, when in fusion, throw some sulphur in, pour it out as before, and the copper will be in the scoria; the remaining regulus being brought in fusion again, and sulphur added and poured out as before, the lead will be in the scoria, of which the regulus being separated and melted again, and proceeded as before, the silver is in the scoria, and the remaining regulus consists now of nothing more but of regulus of antimony. But when you have separated the iron and copper, as above directed, and only the lead, silver, and regulus of antimony, are remaining in the regulus; then you may proceed with another method of separation, which is thus. The regulus of antimony will fume away by itself in a gentle fire, and chiefly when assisted by air, in the manner as it is done with gold by the blast after it has been fused with antimony. Bring therefore this mixture of lead, silver, and regulus of antimony, in a crucible, when in fusion, direct the blast of bellows upon the surface of the

melting

melting matter, and the particles of antimony swimming on the surface, will rise in brown fumes, but the particles of lead and silver, as the heavier part, will sink down to the bottom and remain safe underneath the antimonial mixture; till, going on with the blast, all the regulus of antimony is fumed away, which you may observe when, instead of a brown smoke, grey fumes rise, these being now the lead; and then the remaining matter being only lead and silver, must be finished upon a test.

PROCESS LXXVII.

To dissolve the sulphur of antimony by means of iron, and to precipitate therewith the regulus of antimony.

Method.

1. Let one part of iron, either in filings, nails, or other small pieces, grow red-hot in a crucible, throw successively two parts of crude antimony into it, and the iron will soon be dissolved. When it is in fusion, throw a fourth part, in proportion to the antimony, of pure dry salt-petre, or of fixed alcaline salt in, stir it with an iron hook, and when it flows quite thin, pour it out in an iron cone, made warm and greased withinside with tallow, knock with the tongs gently at the side of the cone to make the regulus settle, then let it cool without moving, Regulus of antimony

moving, invert the cone and ſtrike at the bottom, and the lump will fall out, of which the lower part is the regulus of antimony, and muſt be ſtruck off from the ſcoria with a hammer.

2. Pound and grind this regulus to a powder, mix it with a fourth part of crude antimony, let it melt again, and when in perfect fuſion, throw a ſixth part of good dry ſalt-petre, ſucceſſively in, leave it about ſix or eight minutes longer in the fire, then pour it out, and do as before. If you will, this melting with the ſalt-petre may be repeated once or twice more, adding but a ſixth part of it when in fuſion, by which the regulus will be made purer indeed, but looſe at every time more of its ſubſtance. The ſurface of this regulus preſents the figure of a regular ſtar.

Obſervation.

1. According to the preceeding Proceſs, the regulus may be precipitated likewiſe out of the antimony and ſeparated from its ſulphur by other metals, but as the iron unites better with the ſulphur than any other metal, the ſeparation ſucceeds beſt with this metal. Salt-petre is added chiefly in order to render therewith the irony and ſulphurous ſcoria more fuſible, which otherwiſe could not ſo eaſily be ſtruck off from the regulus when cold, beſides that in the ſame time it deſtroys better the ſulphurous part of the antimony; for, ſalt-petre detonates with ſulphur, and as by this detonation its acid has been expelled and then remains in the ſhape of a fixed alcaline ſalt, it diſſolves, as ſuch, a real part of the ſulphur

sulphur and constitutes therewith a hepar-sulphuris, which swallows readily up the iron and prevents consequently its falling down and mixing with the regulus in so great a quantity as it would otherwise do.

2. As however some part of the iron has mixed among the regulus of antimony in the first melting, some crude antimony must be added again at the second operation, the sulphureous part of which destroys then all the iron remaining in the regulus and reduces it to a scoria. And by this the regulus must needs be entangled again with some impurities of the sulphur.

3. Therefore it is necessary to cleanse it again from that sulphur, and this succeeds better with salt-petre than with the fixed alcaline salt: For, the salt-petre expels the sulphur by two reasons; first, it inflames or detonates with it, and thereby destroys part of the sulphur; secondly, it acts likewise after the detonation as a fixed alcali, and as such dissolves the sulphur. Whereas a fixed alcaline salt alone dissolves the sulphur indeed, but makes then a very strong hepar with the sulphur, which destroys a part of the regulus itself. Hence even those who endeavour to purify the regulus of antimony by a too often repeated melting, tho' but with salt-petre, will render it not so much the purer, as rather destroy it, so that at last little or nothing remains.

4. These scoria being dissolved by boiling in water, then some vinegar dropt in the solution, a great stench will instantly arise, and then a powder precipitates, which when edulcorated and dry, is called the *gold sulphur of antimony*, because when rubbed upon silver, gives it the colour of gold.

PROCESS LXXVIII.

To purify gold from the admixture of other metals, with the sulphur of antimony, or to fuse the gold through antimony.

Method.

Fusing gold thro' antimony

1. Let the gold grow red hot in a good crucible, take twice as much of the best antimony such as has fine long stria, pounded into a coarse powder, throw it successively upon the heated gold, so that always the mixture may fuse thoroughly before you throw in any more. Cover the crucible, for if coals should fall in, they would cause an ebullition; when all the antimony is brought in and in perfect fusion, and some sparks appear to push out on the surface, pour it out into a cone made warm and greased with tallow, knock a little upon the stone or place whereupon the cone stands to make it shake, and by that the regulus sinks to the bottom; when cold, turn the cone, take the lump out, and break the scoria off from the regulus, which will be of a yellowish colour and consist of gold and regulus of antimony. All the other metals which were mixed with the gold, being dissolved

solved by the sulphur of the antimony, are contained in the scoria, besides a small portion of gold.

2. Let this regulus melt again in the same crucible with two parts of antimony in the manner as you did before, and the gold will be still purer. The regulus obtained may be melted a third time, with as much antimony only as the regulus weighs.

3. Bring the regulus in a draught-furnace upon a clay test, or better in a good strong crucible, to prevent the falling in of coals, and to have at the same time better convenience for raising the fire when required. Give at first a gentle heat so that the regulus may just be but in fusion and shew always a bright surface, then blow gently with the bellows upon that surface, and the fumes which rose before but faint and thin, will instantly thicken and raise more abundantly, and lessen again when you leave off blowing. The more now of the antimony is gone off in fumes, the more the fire must be raised, so that the matter may always remain in fusion and shew a bright surface. When no more fumes are perceived, and the gold perfectly flowing, plays with a fine green colour on the surface, then throw a little salt-petre and borax from time to time in, and when it has fused a little while therewith, pour it out.

Observation.

1. Since sulphur dissolves every metal, and renders it to a scoria, except gold and zinc,

the gold must of course be separated and freed by that means from all other metals. But the common raw sulphur being too volatile, and burning away before it can perform the solution of those metals in fusion, antimony is taken as a substance in which the sulphur is more bound up by its reguline parts and consequently more fixed in the fire. This reguline part of the antimony falls then indeed to the bottom along with the gold, so as to mix both together, while the sulphur dissolves the other metals during the fusion; but since that regulus is so volatile as to go off in fumes when exposed to a continued heat, it may by that means easily be driven out from the gold as a body which remains always fixed in the fire, after the manner before mentioned. Besides this, the falling down of the reguline part of the antimony during the fusion, has the good effect of collecting the smallest particles of the gold dispersed among the scoria.

2. The second and third melting takes place, in order to dissolve such parts of the foreign metals as may yet remain in the gold, by a fresh portion of the antimonial sulphur. For, there will after all remain some few particles of silver and copper among that gold which has been fused through antimony, so that when afterwards dissolved in aquaregis, commonly some silver is found at the bottom in a black powder.

3. If gold has too large an admixture of other metals, then it would require so much of the antimony, and consequently so great a quantity of the reguline part of the antimony would be communicated to the gold, that the driving out the regulus from the gold would take too much time and work. To prevent therefore this inconvenience, a part of common sulphur must be mixed in that case with the antimony.

4. Regulus of antimony fuses in a much less degree of heat than gold; the more therefore of the former is gone off in fumes, the more the fire must be raised, because the mixture growing finer, requires then very near the same heat as gold itself. Lastly, some saltpetre and borax is added in order to destroy whatever may remain of the reguline particles among the gold.

PROCESS LXXIX.

o dissolve mercury with sulphur and to make cinnabar of it.

Method.

1. Let one part of pure sulphur, or of flowers of phur, melt in a flat earthen vessel over a very tle heat, take two or three parts of live mercury a soft leather, squeese the leather that some Cinnabar

of the mercury may pass through it and sprinkle in small drops all over the melted sulphur, and the matter will become thicker; stir it continually with a tobacco pipe, then squeese more of the mercury into it, stir the mixture, and proceed in the same manner till all the mercury is brought in, and it will become a black shining substance. If it should take fire by having raised the heat too much, cover the vessel and take it off from the fire till the flame is quenched.

2. Grind this black matter to a powder, put it in a cucurbit or a retort, and order it in a sand-coppel, fill it up with sand so as to reach a little above the substance contained in the cucurbit. Give first a gentle fire, but raise it then as quick and as strong as the vessel can bear; and at the uppermost part some white flowers besides a black substance will appear, but near the bottom the cinnabar. Look into the bottom of the vessel if all or most part has sublimed; and if so, let it cool by itself, break the vessel, take out the cinnabar, which has collected in a solid ring by itself in the lowermost part of the vessel, grind it to an impalpable powder upon the marble. The blackish matter, which must not be mixed with the cinnabar, may be kept for further use to the like operation.

Observation.

1. Mercury unites so readily with sulphur that even when both are grinded cold in a mortar of glass or marble, they unite and turn into a black powder, though it requires some time and

and labour, and then it has the name of *Æthiops Mineralis.* Æthiops Mineral.

2. The quicker the fire is raised, the deeper and finer will be the colour of the cinnabar. Cinnabar however when in whole lumps, never shews a very bright colour, but looks almost like a hæmatites. But the finer it is ground, the finer and richer it shews the red; and if by the grinding it should not prove of a fine red, it must be sublimed again.

3. Sulphur as well as quickfilver, when each by itself, will sublime in a much less degree of heat than when united into this compound. Whence we may conclude that the matter collected about the cinnabar, must be either the superfluous sulphur contained in the mixture, or that part of mercury which had not united thoroughly with the sulphur.

PROCESS LXXX.

To dissolve the sulphur contained in cinnabar by means of iron, and so to reduce it again into live quicksilver.

Method.

Grind one part of cinnabar with two parts of iron filings well together, put it in a glass retort and order it in a sand copple, fill it all up with sand, give the fire by degrees, till the quicksilver Quick-silver.

goes

goes over into the receiver in its current form. Laſtly, lay ſome hot coals upon the top of the retort, to make the quickſilver, ſticking in the neck, run down. The retort muſt in this operation lie as much declining with the neck downwards as poſſible, elſe the mercury collecting in the neck will fall back into the retort inſtead of running forwards into the receiver. The mouth of the retort may either be quite immerſed in the water which is in the receiver, or at leaſt ordered ſo that the hot globula of the mercury may fall immediately in the water without touching the receiver, becauſe otherwiſe they would make the receiver crack in pieces. For, the water in the receiver ſerves to no other purpoſe than for cooling the mercury.

Obſervation.

1. Sulphur diſſolves indeed every other metal ſooner than mercury, except gold and zinc, wherefore mercury might as well be ſeparated from the ſulphur with copper, tin, &c. to recover its live form again. But ſince iron is by far the ſtrongeſt diſſolvent of ſulphur, and the ſame quantity of ſulphur requires leſs of iron to its ſolution than of other metals, it is more convenient to take iron to this ſeparation. For the ſame reaſon this operation ſucceeds better with iron, than with an alcaline earth, or with a fixed alcaline ſalt, by making therewith a hepar-ſulphuris. (See the following Proceſs.)

2. From this and the LXXVIth Proceſs appears now the order after which metals are to be diſſolved

dissolved by sulphur, viz. the first is iron, then copper, then tin, after this lead, then sulphur, then bismuth, after that regulus of antimony, then mercury, and at last arsenic. **Order of solution.**

PROCESS LXXXI.

To dissolve the fixed alcaline salt with sulphur, and to make therewith *hepar-sulphuris*.

Method.

Hepar-sulphuris. Make a perfect mixture of one part of sulphur, and of two parts of a pure, dry, fixed alcaline salt; bring this mixture successively with a ladle in a red-hot crucible; take care that none may be brought in 'till the former is in fusion. Stir it sometimes with a tobacco-pipe, cover it then, and let it well melt; then pour it out, and a brown red substance, very nauseous in taste and smell, will be obtained, which when exposed to the air, soon turns into a black liquor, and has only from its colour the name of *hepar-sulphuris.*

Observation.

1. The fixed alcaline salt dissolves with every acid as readily as with a phlogiston. In the first case, it makes a neuter salt, in the other, a soap. Since then sulphur consists of a phlogiston as well as of a vitriolic acid, it is dissolved by the fixed alcali with respect to both its

its constituent parts, and then makes up a composed body, partly similar to a soap; partly to a neuter salt.

2. This hepar-sulphuris when dissolved in water, and any acid, even the weakest kind, is brought into it, its offensive smell becomes much stronger; (like that of rotten eggs) and then a white powder precipitates which has the name of *sulphur-milk*, and is no more than a real sulphur. For, when a fixed alcaline salt is brought in fusion, and half as much coal-dust thrown in, the same brown-red stinking matter is obtained. Even some few drops of oil of vitriol being thrown upon burning coals, will produce the same offensive sulphureous smell, in every respect similar to that of the hepar-sulphuris.*

3. Commonly fixed alcaline salt dissolves the acid of vitriol with more power than any other

* Hence when silver stains so easily in some places, we may conclude, that the air must be more replete with those sulphureous-phlogistic particles than in other places, and that it must arise from a great abundance of mineral fumes communicated to the air either by the use of a mineral fuel, or by the smelting of mineral substances in great quantities. And though the colour of this stain communicated to silver, is commonly black, yet it may be observed as a curiosity, that in the royal smelting-houses near Freyberg, in Saxony, those large silver-corns which are kept from the assays of the richest silver-ores in the assaying-office, acquire instead of a black, a gold yellow colour so bright and perfectly similar to gold, that they are no more distinguishable from real gold, after having lain for some time in that place by themselves.

other ſubſtance; wherefore every other kind of acid may be expelled from it by the vitriolic acid. However, in the hepar-ſulphuris even the weakeſt acid will ſeparate the vitriolic acid along with the phlogiſton from the fixed alcaline ſalt, whence it appears that the acid of vitriol diſſolves the phlogiſton with more power than the fixed alcaline ſalt; and this is further proved when a vitriolic neuter-ſalt is brought in fuſion, then ſome coal-duſt thrown into it, as from thence an artificial ſulphur will be obtained.

4. From this ſolution and from the colour and ſmell which it produces, the exiſtence of ſulphur in any foſſile body may be diſcovered, by melting it only with a fixed alcaline ſalt in the fire.

PROCESS LXXXII.

To diſſolve the ſulphur of antimony with a fixed alcaline ſalt, and to free therewith the regulus of antimony from its ſulphur.

Method.

Grind three parts of ſalt-petre, as much of tartar, and four parts of a pure crude antimony, each by itſelf to a fine powder; mix afterwards all three ſubſtances well together; bring it in a warm place to become thoroughly dry. Of this mixture throw Regulus of antim.

but

but a little (for example, a quarter of an ounce) at a time, in a pretty large crucible made red-hot, and it will inflame with great noise and sprinkling sparks. When this has subsided, and the matter is become thoroughly red-hot, then throw the like quantity of fresh mixture in, do as before, and go on 'till all is brought in. Then put a cover on the crucible and let it come to a perfect fusion; pour it out in an iron cone made warm and greased with tallow; when cold, turn the cone, and the lump will fall out, which consists of regulus of antimony collected by itself at the bottom, but all the rest above it is hepar-sulphuris.

Method.

1. This operation requires a large crucible, else part of the matter would be dissipated by the detonation, and for the same reason the matter must be brought in by degrees in small quantities. But great care must be taken that all has first detonated and is grown perfectly red-hot, before any more is brought in; for if the matter which has thus detonated, should become in any degree cooler than ordered, it would immediately acquire a hard dark crust on the surface, and this soon be followed by a terrible explosion capable of killing those near it. The reason is, because salt-petre with the phlogiston and the alcaline salt contained in the tartar, produces the effect of gun-powder.

2. Part of the sulphur in the antimony becomes already destroyed by the detonation of the salt-petre; but this sulphur is afterwards chiefly

chiefly and more destroyed when the salt-petre has been reduced into an alcaline salt after the detonation; and being by that means changed into an hepar-sulphuris, it makes the regulus of antimony, as being now freed from its sulphur, sink down through the scoria to the bottom by its own gravity, leaving the sulphur in an united and dissolved substance with the alcaline salt behind as an hepar-sulphuris. The regulus presents upon its surface a star, because it is made up of a striated texture, which from the narrow and pointed centre at the bottom extends into a large flat and round surface at the top. This regulus being melted again with a fixed alcaline salt, it will make another such scoria or hepar-sulphuris, and is perhaps never to be freed entirely from its sulphur, and therefore always remains a brittle semi-metalline substance.

PROCESS LXXXIII.

To dissolve metals with hepar-sulphuris.

Method.

Let those metals which require a strong fire to their fusion only grow red-hot; but such as will fuse in a little heat, come to flow; throw successively four parts or more of hepar-sulphuris, made warm, and reduced into a fine powder, into it, and if

Hepar-sulphur.

if gold, twelve or more parts. Let it fuse and work a few minutes longer in the fire, and pour it out.

Observation.

Why it destroys all metals

1. Gold, dissolved with hepar-sulphuris, presents a brown-red substance, which when diffused in water and filtered, leaves a brown-red powder in the filtering paper, which consists indeed mostly of sulphur, yet contains some of the gold likewise. The filtered solution acquires a deep yellow colour, similar to a solution of gold made with aquaregis. Upon pouring some vinegar into it, it precipitates a powder, which is the gold dissolved by the sulphur; edulcorate this powder, and bring it when dry, in a crucible; make it red-hot, and the remaining sulphur will be expelled, and the gold be obtained again.

And even gold.

2. Though gold may not be dissolved by sulphur alone, but burns away without affecting in the least this noble metal; yet we see in this case that when the sulphur has been bound up, and acquired a greater fixity by a fixed alcaline salt, it is then able to dissolve the king of metals, and to destroy it into a mere scoria.

3. Other metals are partly swallowed up by the hepar-sulphuris, and sink mostly by themselves down along with the sulphur, partly, such as silver, lead, copper, and iron, attract the sulphureous part out of the hepar-sulphuris, and make therewith a brittle regulus.

4. With

4. With ſome metals the alcaline ſalt will indeed perform partly that ſolution, (See Proceſs XXVIII.) Yet the chief power of the hepar-ſulphuris ariſes from the ſulphur being united and fixed with the alcaline ſalt.— Whence it follows, that the more of ſulphur it contains, the more it will be able to diſſolve.

PROCESS LXXXIV.

To diſſolve metals with arſenic.

Method.

Reduce thoſe metals which require a ſtrong fire to their fuſion, into filings or thin lamina; then make a mixture of arſenic, of a fixed alcaline ſalt, and of any ſubſtance which contains moſt of a phlogiſton, ſuch as coal-duſt, ſoap, or tartar; make with this mixture and the metal a good crucible full, *ſtratum ſuper ſtratum*; apply a cover with a ſmall hole at the top; give firſt but ſuch a heat as the arſenic will bear without diſſipating in the fire, then raiſe the fire ſuddenly, and ſo much, that all may come in fuſion. Or, if you will, mix only the metal with an equal part of tartar, and half a part of arſenic; bring the mixture in a crucible which is already red-hot, and melt it inſtantly with a quick fire, and the ſame effects as above will enſue. Arſenic.

But

But these metals which will melt in a little heat, may come in fusion, and the arsenic in powder be thrown in.

Observation.

1. This is the usual method to change copper into a white metal. However, if but a small part of the arsenic is added, the copper will not acquire the desired whiteness; and when too much, the colour will be white indeed, but then it grows brittle. Yet this brittleness may in some measure be helped, by melting such a mixture which contains too much of the arsenic, for several times again with some tartar and borax, because this will extract the superfluous arsenic from the copper. Yet it remains still nothing else but copper, which in the air stains into a black and dull colour.

2. Tin with arsenic falls soon into a calx or ashes, in which part of the arsenic remains united. But that part of the tin which will not calcine with the arsenic, presents a very white and bright metal, of a foliated texture, and resembles pretty much zinc in its form, but not in its other properties.

3. Lead with arsenic works and fumes in a much less heat away, than when by itself. Part of the lead goes off in fumes, but the other part vitrifies into a yellow saffron glass or lytharge, and what remains is a brittle, dark-coloured kind of lead.

4. Gold

4. Gold and silver grow brittle with arsenic; and if driven out with a strong fire, is able to carry off part of the noble metal with the fumes.

5. Arsenic dissolves the soonest and readiest of all, iron; then lead, then tin, and at last silver. Hence all the other metals may be freed from arsenic by iron. Cobalt and arsenic make a blackish shining mixture, and dissolve readily one another, though some will assert the contrary.

PROCESS LXXXV.

To dissolve metals with regulus of antimony.

Method.

Such metals as require a strong fire to their fusion, must be made red-hot in a crucible; but the other which will melt in a little heat, may be brought to fuse; throw the regulus of antimony, when reduced into a powder, to the metal, cover the crucible, and give quickly a strong fire in proportion as the metal requires. Regulus of antim.

Observation.

1. *Regulus of antimony* dissolves the metals in the same order as arsenic, viz first and most readily iron, then copper, then lead, then tin, and at last silver.

2. *Regulus of antimony*, when kept in a continual and proper heat, dissipates mostly by itself in fumes, though slowly. But when an agitated air is applied to strike upon its surface in fusion, then it will fume away with great dispatch. Whence this method may be used to advantage whenever it is to be driven out from such metals with which it had been united.

3. But as likewise other metals are much sooner dissolved by sulphur than by the regulus of antimony; the separation of this regulus from such metals may consequently be performed with sulphur.

PROCESS LXXXVI.

To reduce antimony into a glass, and to dissolve therewith the metals.*

Glass of antimony

1. Crude antimony being pounded into a coarse powder, bring it in a flat earthen unglased vessel; make a gentle fire under it, so that the antimony may only fume without melting, and stir it continually. If in this degree of heat no more fumes will arise, increase it a little, and proceed in that manner further on, 'till the fumes are all driven out, and you will have an ash-grey calx; or if it has been calcined at last with a pretty strong heat,

* Except gold and bismuth.

the

the calx will be of a yellowiſh colour. If the antimony ſhould bake or melt together in lumps, which in the beginning it will readily do, it muſt be taken off and ground again. The fumes which riſe during the operation are very noxious, it muſt therefore be performed either in the open air, or under a chimney of a very good draught.

2. Bring this calx in a crucible, cover it that no coals may fall in, let it come to flow quite clear, and a few minutes remain in fuſion; then pour it out upon a dry and warmed marble, and you have a dark yellow, ſemi-pellucid glaſs.

3. Let thoſe metals which require a ſtrong fire to their fuſion, grow red-hot in a clay-teſt or flat-pot under the muffel; and ſuch as will flow in a little heat, let them come in fuſion; put this glaſs into it when before ground to a fine powder; let it flow perfectly clear together for a little while, and the metal will be deſtroyed and vaniſhed more or leſs according to the different property of the metal. But biſmuth ſuffers no alteration with this glaſs.

Obſervation.

1. This glaſs is not only a powerful diſſolvent of earths and ſtones, but likewiſe of metals, ſo that gold only and biſmuth may not be affected by it. Whence in the aſſaying of ſuch ores as are interſperſed with antimony, it often happens that little or no metal will be obtained. For, while you give to ſuch ores a gentle roaſting, the antimony is thereby re-

duced into a calx; this turns then by the subsequent fluxing of the ore, into a glass of antimony, and consequently the metal contained in the ore, or part of it, must needs be destroyed. Besides this, the antimonial regulus, even before it is destroyed, is able to carry off part of the metal in a strong fire, assisted by the action of the air. But when this regulus is first precipitated along with the other metals by means of iron, or irony ores, and then suffered to go very slowly off in fumes, according to the method given in Process LXXVI. then the perfect as well as imperfect metals may be obtained almost without any loss.

2. In physic this glass is used for an emetic, viz. by pouring wine upon it in a bottle, and leaving it with the wine for some time together, by which the wine acquires the property of vomiting, without any perceptible decrease of the mineral glass. Besides this, various other medicines are prepared from antimony.

PROCESS LXXXVII.

To dissolve metals with bismuth.

Method.

Those metals which require a strong fire to their fusion, put along with the bismuth in a covered crucible; but such metals as will melt in a little heat

heat, may be fused with the bismuth in an open crucible.

Observation.

1. Bismuth being brought to such metals which by themselves will not melt but with a strong fire, renders them fusible, so that they will flow in a far less heat. But then they become brittle, and acquire a whitish colour. To lead it gives a very peculiar property, viz. when united with bismuth in fusion, and then an amalgama is made with this mixture and mercury, the lead unites so intimately with the mercury, that it will for the most part go with the mercury through the leather. The same amalgama being kept for some days in a gentle warmth, it expels the bismuth by itself in the form of a white powder, but the lead remains in the same rarefied state among the mercury.*

2. Though bismuth and zinc bear a great resemblance to one another in their semi-metallic form, so that some authors confound these two minerals frequently, and mention both promiscuously for the same thing; yet they are so very different genera, that they will even not unite in fusion, though assisted by mechanical motion. For, notwithstanding

* This is a secret practised by those who deal with mercury, as this is considerably increased by it in weight, and may not be discovered but by subliming the mercury.

they seem to have dissolved one another, after being fused together, yet the contrary is soon discovered by breaking the mixture asunder with the hammer, because they then are found only sticking together; so that the zinc makes the uppermost and bismuth the undermost stratum. Moreover, when this mixture is brought to fuse in a very gentle heat, the bismuth, as the easiest to flux, will run like water, while the zinc remains entire and may be taken out with the tongs unaltered.

3. If you desire to recover the bismuth from those metals with which it has been united, without any loss, proceed after the method given in Process LXXVI.

4. Bismuth being united in fusion with other metals or semi-metals, each equal parts, the mixture will always retain the texture of bismuth, except with tin, to which it communicates only a finer grain.

PROCESS LXXXVIII.

To dissolve metals with zinc.

Method.

Zinc. Reduce those metals which must be fused by a strong fire, into filings or thin lamina; let them grow red-hot in a crucible, then melt the zinc by itself in another pot, and pour into it the heated metal;

metal; throw ſome tartar and powdered glaſs to it, and raiſe the fire ſuddenly. But the other metals which will melt by a little heat, may come in fuſion, and the zinc thrown into it, and the mixture will ſoon melt together.

Obſervation.

1. Zinc being brought in a ſtrong fire, it inflames, and burns with a violet-coloured flame, and ſo diſſipates, partly in fumes, partly collects in white flowers. For this reaſon, the fire muſt in this operation be ſuddenly raiſed before it has time to fly off: and this is at the ſame time prevented by the tartar and glaſs, which ſwimming at the ſurface, prevents its volatility.

2. Lead and tin looſe partly their malleability, more or leſs, according to the quantity of zinc which has been added. Copper obtains a gold yellow colour with the zinc; and if more of the zinc is added, the colour will be the finer, but then it grows the more brittle; and if the zinc is added in leſs quantity, it remains indeed more malleable; but then the red copper colour prevails again.

If the mixture is made of four to ſix parts of copper, with one part of zinc, it is called *prince-metal*. If more of the copper is taken, the mixture will be a deeper yellow, and then goes for *tompac*; ſo as even copper by itſelf has given that name when only its ſurface is ſtained by the fumes of zinc with a gold yel- **Prince metal.** **Tompac.**

low

Gilding copper with zinc.

low colour; which is done by mixing flowers of zinc with coal duſt, throwing that mixture into a heated muffel, and then holding immediately a piece of red-hot copper in the fumes or flowers riſing from the zinc.

PROCESS LXXXIX.

To diſſolve copper with zinc when in its ore, and to make braſs of it.

Method.

Braſs.

Pound lapis calaminaris to powder, take one part and a half of that, and as much of coal-duſt, (by meaſure not by weight) mix it well together, moiſten it a little with water, take a crucible or any veſſel which may bear a melting heat, fill it with this mixture, ſo that part of the copper-lamina lie among the powder, but all the top be covered with theſe lamina likewiſe, then cover the copper which lies uppermoſt with coal-duſt, and upon this lay plenty of charcoal. Give from one to two hours a gentle heat, raiſe then the fire ſo that the pot may grow red-hot, and in that degree let it remain for ſome hours. Then take the veſſel out, let it cool by itſelf, or if there is a great quantity, pour it out in a warm ingot; the copper will be changed into a yellow metal, (braſs) and has increaſed in weight and bulk, ſometimes from a fourth to a third.

Obſervation.

Observation.

1. In this operation a double process of chymistry or metallurgy is at once performed. First, the zinc is melted out of its ore in its metallic form, and then it is immediately, and at the same instant united with the copper. For, when the calamine is mixed, as abovesaid, with coal-dust, and distilled in an earthen retort, the zinc is obtained by itself in its metallic form. (See Process LXXIII.) As therefore the zinc in the present operation is likewise reduced in its metallic form, it would all dissipate again in fumes, if the mixture which lies above did not obstruct its way; so that still some part of it goes off, as appears by the zinc flowers which always collect in these furnaces. But as it meets with the heated copper above in its way, it penetrates that metal, dissolves, and unites with it, increases its bulk, and changes its colour into that of brass; (see the observation of the preceding process) and then the copper is rendered so fusible by this semi-metal, as to flow in a far less degree of heat than by itself. Theory of making brass.

2. This metal, called *brass*, being made in this manner, remains perfectly tough and malleable when cold. But if it is made by uniting the zinc in its metallic form with the copper in fusion, then it makes a brittle metal. The reason of this difference is probably this, that when the zinc is in its ore, it penetrates the copper

copper only by degrees with its fumes, and unites therefore more intimately with it; whereas when both are united in their metalline fubftance, it cannot fucceed with the fame effect.* Befides this, zink as it is fold in warehoufes, is frequently adulterated with other ingredients, fuch as will render the copper brittle; though fuch zinc may eafily be cleanfed of all thofe impurities by means of fulphur, becaufe this and the gold are the only metals which can not be affected by fulphur in fufion. Brafs, and any of the above yellow metals, loofe their malleability entirely fo foon as made moderately hot, fo as to break in pieces by the leaft touch with the tongs.

3. There are feveral other mineral fubftances, befides calamine, of which brafs may be made, being either naturally or artificially impregnated with zinc, fuch as black blend, red blend, foot of brafs founderies, (called oven-bruch) flowers of zinc; only with this difference, that fome produce more, fome lefs of brafs with the copper, or that they give it a finer or a worfe colour. Some of thofe ores or compounds, if they contain fulphur or arfenic, or both together, muft firft be roafted, becaufe both, the fulphur as well as arfenic, would not only diffolve the copper, but uniting therewith

* I would rather think that the zinc has loft in its preparation that mercurial part which is originally contained in the ore and which unites fo readily with the copper and preferves its malleability.

during

during the operation, render it a base metal. However it cannot be helped but great part of the zinc itself must be driven out and lost by the roasting.

PROCESS XC.

To dissolve the metals with lead.

Method.

1. Let the lead come to work and fume in a clay-test or in a crucible, put then the metal, either copper, silver, gold, &c. into it, which must be reduced into thin lamina or small pieces, and the driving and working of the lead will instantly increase, so that those metals which would require a much stronger fire to their fusion by themselves, will be swallowed up and disappear almost instantly.

2. Tin and lead dissolve one another with little more heat than what they require to their fusion. But if the fire is but raised so much as to make the vessel moderately red-hot then both are destroyed and reduced into a calx, which is either of a white, yellow, or reddish colour. If this calx is removed from the surface with an iron ladle, the surface is then immediately covered with another such crust of calx, so that in a little time a great deal of tin and lead may be reduced into a calx, which consists nearly each of the same quantity of both metals.

3 With

3. With cobalt, the lead unites but in a very small quantity, most part of the lead adhering only to the cobalt, which as the lightest is found uppermost, when cold.

Observation.

Theory of Draining (Sikering.)

1. Lead dissolves gold and silver sooner than copper. This, and because lead melts in a little heat, but the copper requires a strong fire to its fusion, has furnished the principle of that useful separation of gold and silver from the copper by means of lead, which is known by the name of *sikering.* (*draining.*) For, when a copper which contains silver and gold, is melted together with lead in a strong fire, they dissolve each other. This mixture being brought upon an iron hearth which lays somewhat declining, and a slow flaming fire made under it, the lead, with that part of gold and silver which it has dissolved, runs out by degrees and leaves the copper behind in the form of a honey-comb. If the lead has not been added in a sufficient quantity, the pores are too small as to give it room of running off; and if too little of the copper has been added, then the copper does not remain in a compact body behind, but will partly be carried down along with the lead in small lumps. Experience has therefore proved that not above four times as much, and no less than two and half part of lead, in weight, must be added to the copper. With the first fire only the greatest part of the lead is drained out, so that still a considerable part of it remains among the copper. Therefore this copper

copper is then brought in another furnace where a ſtronger fire is given, and then indeed moſt part of the lead is drained out, but at the ſame time a great portion of the copper is carryed off along with it; therefore this laſt ſort of the drained lead, as it is yet too rich of copper, muſt not be brought immediately upon the teſt, but is to be melted afterwards among a freſh parcel of copper and lead at the next operation, by which means that part of copper, which would have been loſt upon the teſt, is ſaved. Yet there remains ſtill a part of lead in that copper which has undergone the ſecond fire, which lead, as it contains likewiſe a proportionable part of gold and ſilver, it muſt needs follow that the richer that copper is of thoſe metals the more remains behind among it after the firſt operation; therefore ſuch rich copper muſt either be twice drained, or mixed with other poorer copper, ſuch as would not pay the expenſe of being drained alone; by which means the poorer ſorts of copper may be worked to advantage. Commonly this operation, with reſpect to the proportion of lead and copper, is performed and ordered in that manner, viz. So many lumps of lead, weighing each ſeventeen pound weight, are added to the copper, as the mixture when melted together, contains half ounces of ſilver,* deducting however as much as the copper contains already of lead. Whence an exact aſſay muſt firſt be made of the

* For the Germans reckon by half ounces, which they call loths, ſo that a pound weight contains 32 loths.

the copper as well as of the lead how much each contains of silver. If it then appears that so many half ounces of silver are contained in the mixture, that these lumps of lead each of seventeen pounds weight, should make up more than four times as much as the copper, the proportion must either be made even by adding so much more of poor copper, or the sikering must be repeated twice. By that means a hundred weight of copper which contains but a quarter ounce of silver, may be worked with profit. With the raw copper, called by the Germans *black-copper*, this operation succeeds better than after it has been refined, because the former contains a portion of sulphur, and as this unites easier with the copper and dissolves it readier than other metals (except iron), the separation of the gold and silver from the copper is thereby greatly helped. Instead of lead, other mixtures containing lead, such as lytharge, old tests, and the like, may be added to the copper with equal success, but then they must be melted together with the copper in a great furnace, call'd the *frish-oven*, where the lead is reduced into its metallic form and thereby united with the copper; but then the right proportion of each quantity must be found and the operation disposed accordingly. Commonly an hundred and twenty-five pounds of lytharge are taken instead of an hundred weight of lead. The cakes or lumps contain commonly not above three quarters of a centner of copper, and two or three hundred weight of lead.

2. Lead never unites with iron, when both in their metallic ſtate. Hence iron proves a very proper ſeparator to the parting of ſilver from tin, which otherwiſe by the common method with lead is very expenſive and difficult to perform. The method is this: Melt your tin which contains ſilver, firſt with lead, then throw ſome clean iron filings together with ſome alcaline ſalt into the melted mixture, and the lead will take up all the ſilver contained in the firſt, while the tin is entirely diſſolved (ſwallowed up) by the iron, and conſequently ſeparated from the ſilver which is now among the lead; the alcaline ſalt helps to make the ſcoria fuſible. To part ſilver from tin.

PROCESS XCI.

To diſſolve metals with tin.

Method.

Let the gold, ſilver, copper, or iron, when reduced into lamina or file-duſt, grow red-hot in a crucible, pour the melted tin into it, throw inſtantly ſome tartar, ground glaſs, and potaſhes upon it, raiſe the fire ſuddenly, and when all is in perfect fuſion, pour it out in an ingot, and either of the above metals will be reduced into a white brittle metal. Tin

Obſervation.

Observation.

Tin to harden.

1. Silver and gold grow brittle from the smallest portion, even from the fumes of tin, but copper and iron bear a good deal more of it, though they become likewise brittle. If to twenty parts of tin, one part of copper is added, the tin is rendered harder, and remains still soft enough of being worked into utensils and vessels, whence they are more durable than when made of pure tin. The same effect is obtained upon adding some part of a semi-metal, such as zinc, bismuth, cobalt, or regulus of antimony, instead of copper. If to ten parts of copper one part of zinc, or brass is added, a brittle and sonorous mixture is produced usually used for great guns and bells. Whence it has the name of *gun* or *bell-metal.*

Bell-metal.

2. Iron being dissolved in fusion with twice as much tin, a white, somewhat brittle metal is obtained, fit for various uses, and then it wears much better against rusting in the air than the iron does by itself.

PROCESS XCII.

To dissolve metals with iron.

Method.

Iron

Put the iron along with the other metal in a good crucible, throw some powdered tartar and ground glass

glaſs into it, in order to keep the mixture covered therewith when in fuſion, raiſe the fire ſuddenly, and the iron will ſooner and by leſs heat come in fuſion than when by itſelf.

Obſervation.

1. Copper receives from the iron a pale colour and becomes ſomewhat brittle. If therefore copper ſhall be obtained pure out of ſuch ores which have an admixture of iron, it muſt be done in the beginning with the roaſting of theſe ores, as then the iron will be deſtroyed with the very ſulphur contained in the ore in the firſt operation. For afterwards, if the iron has once been ſuffered to unite with the copper in fuſion, it may hardly be parted from it by the uſual methods of refining the copper, except perhaps with lead by means of draining.

2. Gold as well as ſilver unites very readily with iron, gold ſooner than ſilver. But as we know that gold is not affected by ſulphur in the fire, it may eaſily be parted from the iron by the aſſiſtance of antimony, and even ſilver may be parted from the iron with the ſame minerals, becauſe ſulphur diſſolves the iron by far more readily than the ſilver. Lead may likewiſe ſerve for a ſeparator in that caſe. If the leaſt portion of ſulphur is contained among the iron, it can no more diſſolve other metals, but collects then in a ſeparate regulus at the bottom.

PROCESS XCIII.

To dissolve gold and silver with copper.

Method.

Let the gold or silver fuse, throw the copper, when before reduced in small pieces or file-dust, into it, and it will soon disappear and unite with the other.

Observation.

Any other substance which might give to gold or silver a greater hardness, deprives them of their malleability and renders those noble metals brittle. But the copper makes them harder without lessening their malleability. And as gold and silver, when pure, are too soft to serve for most uses, they are frequently and almost always allayed with copper.

PROCESS XCIV.

To dissolve gold and silver together in fusion by themselves.

Method.

Rub first the inside of a crucible with powdered borax, put it in the fire, when red-hot, bring the silver

silver and gold together in the crucible, raise the fire, let it fuse for a little while, then pour it out.

Observation.

1. Borax gives the crucible a smooth surface as if it were glazed over, and by this means all the coarse pores of the crucible are filled up, so that none of the precious metal can stick to the inside, as it always happens without using this method.

2. Sulphur dissolves silver, but not the gold; hence the silver may be separated again from the gold by means of sulphur, and this parting is called the *parting of gold and silver in the dry way.* This method is of very great use when the silver contains so small a portion of gold that it would not pay the expence of the aqua-fortis. The chief requisites of this operation are as follow: The silver when granulated, then moistened with water, must be mixed and well stirred together with a quantity of finely powdered sulphur, by which means every grain of the silver will be covered over with sulphur; this when put in a crucible and a cover luted on with a good lute, must be brought in a gentle heat, wherein it may by degrees come in fusion, and so all the silver be dissolved by the sulphur. With this first operation the purpose is now so far obtained that the small particles of gold are separated from the silver; but as the scoria into which the silver has been reduced by the sulphur, is too copious in proportion to the gold, and too thick and tough as that the small particles Parting in the dry way.

of gold dispersed therein could sink down and collect at the bottom; part of the silver must be made fusible again by disengaging it from the sulphur, in order that so it may be able to collect all the small particles of gold and take them with itself down to the bottom. The silver may be freed from the sulphur either by fire alone, when a melting heat is given to it so long till some white shining granula begin to appear on the surface, as being that part of the silver which is then freed from sulphur. Or it may be done by adding such a substance which unites more readily with the sulphur than silver, such as a fixed alcaline salt, or some other metal. (See Process LXXVI.) Then it must be poured out in a warmed and greased cone, and when cold, the regulus, which consists of silver and gold, be struck off. The same operation must be performed with the remaining scoria, and then the third, and even the fourth time repeated, in case the silver is pretty rich of gold. The several regulusses obtained, must be burnt fine before the blast, and then dissolved in aquafortis. All the silver which remains now in the scoria is obtained again either by burning it only by itself before the blast, or by means of iron and lead, when it all goes into the lead and leaves the iron united with the sulphur behind in a scoria. A further account of this operation may be seen in *Cramer's Docimacy*, and in *Shlutter's Art of Smelting*.

PROCESS

PROCESS XCV.

To dissolve metals with quickfilver.

Method.

1. Give to the metal a clean and larger surface either with filing, laminating, or precipitating it from the acid menstrua in which it has been dissolved; which latter however must not be done in this case with an alcaline-salt, because this would mix with and adhere to the metal, and render thereby this operation either difficult or quite impracticable. Quickfilver.

2. Then grind the metal in a mortar of glass, stone, or iron, with some parts of pure quickfilver, till none of the metal can be more discovered either by the eye or by the touch.

Observation.

1. This solution is greatly helped by heat, therefore it is better to make first the mercury nearly as hot as to begin to fume; and those metals which require a great heat to their fusion, must likewise be made red-hot, but the other which will fuse in a little heat, must be melted and poured into the hot mercury, and then triturated. Iron may not at all be dissolved in that way, as much as we know at present; and regulus of antimony very difficultly, or at least very imperfectly. For, when the antimonial regulus, after

Henkel's method, is melted and poured slowly in hot mercury, which must be brought in hot water in an iron mortar, and then quickly grinded with a pestle, it seems indeed to unite and to dissolve with the mercury, but when this mixture is left for some time in a gentle heat, or even if it is triturated for a longer time, the mercury throws the reguline parts out again. This solution is named *Amalgamation*, and the mixture of the metal and mercury, *Amalgama*.

Amalgama.

2. This method of solution is sometimes made use of for extracting gold and silver from sands and the like stone kinds, as well as from ores. For gold is never found actually mineralised within ores, but always by itself in its native form, and therefore it is very fit for being extracted by that method, provided the sand has before been ground and washed from all its light, earthy, and empty particles, (which the Germans call flemming) and then by the trituration some water must likewise be added besides the quicksilver. But with the silver this operation is somewhat more difficult, because silver is but seldom found native, but commonly in ores, or in a mineralised state. Wherefore this method takes only place with the silver where the ores are either very rich of silver and mostly in its native form, or where fuel is very scarce: and therefore all those particles which would obstruct the effect of the mercury, must first be removed by cleansing and dissolving them with alcaline or other salts. Of a particular kind

kind of *quick-mills*, constructed to this purpose, see *Agricola*, or *Sblutter*. Quick-mills.

3. When gold has been dissolved with mercury, then the surface of other metals may be overlaid and gilt with much less expence than in the cold or any other way. The method is thus: The amalgama must first be mixed with some more quicksilver, so that ten or twelve parts of mercury may come to one part of gold, and the mixture perfectly united by trituration: then the metal which is to be gilt, either silver or copper, must be rubbed with some of this amalgama, together with a few drops of aquafortis, 'till it sticks fast to the metal; the superfluous part must be taken off with a brush, and rubbed smooth with a piece of fustian. The surface being now well painted and covered, the metal is brought upon a very gentle heat of burning charcoal, 'till the mercury is seen to go off in fumes, and the surface is then of a yellow gold colour, but not bright: therefore it must now be scratched with a brass-brush, in a pan with water, and lastly burnished. When large plates are to be gilt, it is difficult to give them all over an equal heat, and to avoid the falling off of some part of the gold: to this purpose they have another method to remedy this inconvenience, which is thus: They cover the whole surface, after it has been overlaid and painted with the amalgama and made a little warm with a *burning-wax*, (glow-wax) so called, and by that means the whole Theory of gilding.

piece

piece, if ever so large, may either at once, or by degrees, be made hot upon a large hearth, and the wax will make the gold as if it were melted on to the surface of the metal. This wax is commonly made of four parts of yellow wax, one part and a half of bolus, one and a half of calcined verdigris, and one part and a half of calcined borax. Aquafortis is employed to eat into the pores of the metal, in order to make the gold insinuate itself and penetrate into the metal. To give to the gold a high colour, the gilt metal is, when properly heated, to be quenched either in urine, or in a water in which the thirtieth part of salt-armoniac has been dissolved. The same end is partly obtained by the burning wax.

PROCESS XCVI.

To part the metals from quicksilver after having been dissolved therewith.

Method.

Put the amalgama in a retort of glass, order the retort in a sand-coppel, proceed after the LXXXth process, and most part of the mercury will rise over into the receiver, and leave the metal behind together with a small part of mercury, which afterwards may be driven out in the open fire, by melting the metal in a crucible.

Observation.

Observation.

Though mercury ſoon flies off in the heat, yet it may not be driven out entirely when in a cloſed veſſel, part of it being in that caſe retained, and as it were protected by the metal. But in an open fire, where the ſurface during the fuſion is continually changed, the mercury is ſoon driven out. Therefore the whole amalgama might be freed from the mercury at once in the open fire, if its loſs ſhould not be minded; but then it muſt be done with a very gentle heat, chiefly at the beginning; becauſe by a ſudden and ſtrong heat ſome particles of the noble metal may be carried off along with the violent fumes of the mercury. For even by an often repeated diſtilling of an amalgama, when done with a ſtrong heat, part of the metal will riſe over with the mercurial fumes, and remain often concealed in the live quickſilver, out of which it can only be recovered by diſtilling it again in a very gentle heat, or by reducing the mercury into cinnabar.

PROCESS

PROCESS XCVII.

To dissolve the calces of metals with glass.

Method.

Glass

Take any mixture whereof glass may be made, (See Process XVI.) or a glass ready made, grind it to a fine powder, mix to one ounce of it some grains of a metallic calx, by grinding both very minutely together; put it in a clean crucible, cover it, and bring it in a glass, or draught-furnace; let it remain in a strong fire for some hours, and you will have a coloured glass according to the nature of the metallic calx.

Observation.

With metals.

1. Metalline calces are prepared either by fire alone, or by dissolvent menstrua, of which they are again freed and cleansed either by fire only, or by precipitating them with other bodies. Of iron and copper, thin lamina or filings may only be brought in a closed vessel into the third chamber of the glass-oven, 'till they admit of being ground to powder. This powder must again be calcined once or twice for some hours longer, in order to calcine and reduce thereby the remaining metalline particles into a perfect calx. Or, let iron filings be only mixed with sulphur, but copper-lamina be laid *stratum super stratum* with

With iron.

With copper.

with powdered sulphur in a crucible, bring it for some hours in the third chamber of the glass-furnace, and the metal will be penetrated and corroded by the sulphur, so as to admit of being ground to powder. If the powder is made of iron, it must be roasted again for a day or two, but that of the copper only for some hours, in the fourth chamber, and in an open vessel 'till all the sulphur is evaporated. Vitriols either of iron or of copper may only be spread on a paper, and laid upon a warm furnace, and they fall in pieces and crumble to powder by themselves, which must be roasted in the fourth chamber, then edulcorated and dried. Iron being moistened with distilled vinegar, then gently dried in a warm place, it will be corroded; and may, by repeating the same moistening and drying often, all be reduced into a dark ash-grey powder, and the copper by the same operation into a verdigris. Both must be roasted in the fourth chamber. **With vitriols.**

Tin and lead are likewise reduced to a calx by fire alone; (See Process XC.) which must be roasted in the fourth chamber, by stirring the calx frequently, then ground and sifted through a very fine hair-sieve in order to separate all remaining metallic particles. How metalline calces are to be made by means of acid-menstrua, either by distillation or precipitation, may be seen in the foregoing Processes. The red-calx, as it is precipitated from gold with tin, makes the fine ruby-glass, by mixing three or four grains of it with half **Tin and lead.** **Ruby-glass**

an

an ounce of glaſs; and in caſe the glaſs ſhould not prove of a red colour when taken out, it will, when made red-hot, and held inſtantly over a flame of dry bruſh-wood, ſoon obtain the deſired colour.

Blue glaſs. Calx of copper, precipitated with a volatile alcali, colours the glaſs blue. Other calces of copper make a green glaſs. Red calces of copper colour the glaſs blood-red; but when left too long in the fire, it turns green. Calcined cobalt colours the glaſs deep blue: if too much is added, for example, an eighth part of cobalt, the glaſs will look black. The ſame happens with the calces of iron; when, however, in the very thin ſplits of the broken glaſs, the red ruſty colour in this, and the blue in the other, will diſcover itſelf pretty plain.

Yellow. Silver, precipitated with a volatile alcali, makes a yellow glaſs.

Two or three parts of lytharge, with one part of calcined flint, makes a yellowiſh ſomewhat greeniſh glaſs. **Milk-white.** Calx of tin renders the glaſs milk-white and ſemi-opake; if a fifth part of ſuch glaſs is added to glaſs-fritt, then it makes a white and quite opake glaſs.

When to a mixture of glaſs and lytharge, as much or more calx of tin is added than of the lytharge, a milk-white glaſs is obtained, to which with the addition of other metalline calces, any degree and ſhade of colour may be given

given. In general, it may be concluded from thoſe given principles, that with different mixtures, and by the different effect and proportions of metalline calces, the glaſs, opake or tranſparent, may be coloured in various manners and degrees. When laſtly it may be obſerved, that the colours will appear different according to the thickneſs or thinneſs of glaſs, and that the proportion of metalline calces muſt be judged according to ſuch circumſtances. **All colours.**

F I N I S.

ERRATA.

Page 40, line 10, (or a pale red) *read*, or purple.
—— 60, laſt line but 7, (cohereing) *read*, cohering.
—— 61, line 10, (viſibly) *read*, viſible.
—— 63, laſt line but 4, (ggenthrum) *read*, gegenthrum.
—— 104, line 13, (piſton) *read*, peſtle.
—— 108, laſt line but 2, (ſolution, a cryſtallization) *read* ſolution and cryſtallization.
—— 132, laſt line but 4, (crud eſtriated) *read*, crude ſtriated.
—— 136, laſt line but 3, (render) *read*, renders.
—— 147, line 21, (thee) *read*, three.
—— 149, line 2, (herd) *read*, hearth.
—— 156, line 15, (not much) *read*, now much.
—— 170, line 2, (chambers) *read* chamber.
—— 250, (Proceſs XXXVIII. *read*, XXXVII.
—— 344, line 9, (immeſed) *read*, immerſed.
—— *ib.* laſt line but 13, (tint) *read*, tin.
—— 176, *before* Some operations, *read* § 283.

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